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ORIGINAL ARTICLES.

I.—Sedgwick Museum Notes.
New Fossils from the Haverfordwest District. II.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XII.)

Phacops (Dalmanites) socialis, Barrande, var. (Pl. XII, Fig. 2.)

THERE is one complete individual of a species of *Phacops* from the *Orthis-argentea* zone of Prendergast Lane, Haverfordwest, showing certain interesting characters which make it worthy of notice. The head is somewhat crushed and imperfect, but the glabella is seen to be large and broad and to expand regularly towards the front; the frontal lobe is transversely rhomboidal and nearly half the total length of the glabella; there are three pairs of lateral lobes, of which the anterior pair is the largest; the second pair is narrower, and the third pair is subequal to the second in size. The first pair of lateral furrows is oblique; the second pair is horizontal and slightly arched forwards; the third pair is slightly oblique and the most strongly marked of all; the occipital furrow is strong and curved forwards in the middle. There is only a narrow median strip of the glabella not crossed by the lateral furrows, for they are rather long and all reach inwards to about the same extent.

The thorax has a prominent axis about three-fourths the width of the pleuræ, which are bent downwards and backwards beyond the fulcrum, which is situated at about half their length. Their extremities are slightly bent forwards and apparently rounded or bluntly pointed; a deep diagonal furrow traverses the whole length of each pleura.

The pygidium is nearly semicircular, with a regular rounded margin, except behind the axis, where there is developed a long, pointed, straight posterior spine, about two-thirds the length of the pygidium. (In this specimen it is bent to one side, owing to subsequent crushing.) The axis is about one-fourth the width of the pygidium at its anterior end, and tapers rather rapidly to

its middle, and then scarcely at all to end with a blunt (?) extremity just within the margin; it is completely annulated to its tip and shows 11–12 strong rings. The lateral lobes consist of 8 pairs of pleuræ, of which the first seven are prominent, gently curved, and separated by deep interpleural furrows, and each is marked by a weak pleural furrow. The pleuræ and furrows die out before reaching the rounded margin, but there is no independent border or marginal furrow to the pygidium. The whole surface of the head, thorax, and pygidium is ornamented with granulations, and there are also a few large tubercles on the frontal lobe of the glabella.

Dimensions.		mm.
Length of whole trilobite		82·0
Length of head		27·0
Width of head	(about)	56·0
Length of thorax		33·0
Length of pygidium (without spine)		22·0
Width of pygidium	(about)	33·0

Affinities.—This species clearly belongs to the early group of *Dalmanites* of Barrande, of which *D. socialis* is the type. Our specimen is closely comparable with the variety of this species termed *proœva*.[1] In the characters of the head, so far as it is preserved, there seems to be no difference; the pygidium, except in the shape of the axis, is identical, and the ornamentation is quite similar. The species recently described by the author as *Ph.* (*Dalmanites*) *Robertsi*[2] differs by the narrower and more elongate glabella, by the shape and fewer segments of the pygidial axis, and especially by the absence of the terminal spine of the pygidium.

Ph. (*Dalm.*) *appendiculatus*, Salter,[3] has a somewhat similar glabella, but the pygidium is more elongate and tapers to the mucronate extremity; the axis tapers regularly, and has fewer rings and an appendix; the ribs on the lateral lobes are falcate and undulate the margin.

Phacops (Dalmanites) aff. incertus, Deslongchamps.
(Pl. XII, Fig. 4.)

There are several pygidia from the Slade Beds of the quarry at Upper Slade, Haverfordwest, which seem to indicate a new species of *Phacops*, the description of which may be given as follows:—Pygidium broadly subtriangular, bluntly pointed behind; surrounded by narrow, depressed, concave, smooth border, not mucronate, but slightly elevated and upturned behind axis. Axis conical, tapering rather rapidly at first and then more slowly to blunt apex, not reaching posterior margin; extending about four-fifths the length of the pygidium, and with a width at front end a little more than a quarter that of pygidium; gently convex, annulated for whole length with about 12 or more rings, but only the first 9 or 10 are distinct. Lateral lobes gently convex, each consisting of a half pleura at front end followed by six simple,

[1] Barrande: Syst. Silur. Bohême, vol. i, p. 552, pl. xxi, fig. 32.
[2] Reed: Geol. Mag., Dec. V, Vol. I, p. 106, Pl. V.
[3] Salter: Mon. Brit. Trilob., p. 46, pl. iv, figs. 11, 12.

slightly curved pleuræ, ending abruptly at concave border, and not corresponding to the axial segments. Each pleura has a short oblique furrow on its outer half. Interpleural furrows distinct and of uniform strength for their whole length. Axial furrows moderately strong.

Dimensions.

	mm.
Length of pygidium	9·0
Width	15·0
Width of axis at front end	4·5

Affinities.—This species in its shape and number of axial rings and pleuræ recalls *Ph. appendiculatus*, Salter,[1] but the pleuræ in the latter are deeply furrowed along their whole length and undulate the margin. In *Ph. Weaveri*, Salter,[2] the segments are more numerous, though the contour and proportions of the pygidium are not dissimilar. *Ph. incertus*, Deslongchamps, as recorded by Salter[3] from the Budleigh Salterton pebbles, has a pygidium almost identical, and apparently it differs only in the possession of a more produced and mucronate posterior end. The Slade form is undoubtedly more closely allied to it than to any other. Salter (*op. cit.*) correctly recognised that *Ph. incertus* belonged to the group characterised by *D. socialis* in Bohemia, and it is difficult therefore to see why he ascribed it in the same work to the subgenus *Acaste*.

Phacops (Chasmops) conicophthalmus, Boeck. (Pl. XII, Fig. 1.)

No member of the subgenus *Chasmops* appears to have been so far described or recorded from the Haverfordwest district. Mr. Turnbull's collection, however, contains two examples, one consisting of a fine head from the Slade Beds of Upper Slade, which may be confidently referred to the British form termed *Chasmops conicophthalmus* (Boeck) by Salter and others, though it is doubtful if it is really identical with Boeck's species. The Slade specimen consists of a cast and external impression, the latter of which shows the surface-characters fairly well. In the shape and proportions of the glabella and of the frontal lobe, 'cat's ear' lateral lobes, and third lateral lobes, it is identical with Salter's figured specimen (*op. cit.*, pl. iv, fig. 25) in the Sedgwick Museum; there is likewise to be noticed the practical absence of the second lateral lobes, which are in most species represented by small nodules; the convexity of the cheeks, position and size of the eyes, and deep furrow round their base also agree, but in our Slade specimen the eye is well preserved and shows the lenses, which are arranged in about 25 rows, with a total number of about 150 lenses in all. The eye-lobe is elevated, prominent, and almost angulated, as Angelin's[4] figure shows, and the genal angles are similarly produced into long, broad, flattened spines, steeply inclined to the general plane of the head-shield and extending

[1] Salter: Mon. Brit. Trilob., p. 46, pl. iv, fig. 12.
[2] Ibid., p. 57, pl. iv, fig. 7.
[3] Ibid., p. 30, pl. i, figs. 27, 28.
[4] Angelin: Pal. Scand., p. 9, pl. vii, figs. 5, 6.

backwards for a distance at least equal to its length. The points of the spines are broken off. Salter (*op. cit.*) described the genal angles as "short-spinous," but his figured specimens have the angles of the head-shield broken off short, so that their true character could not be determined.

The whole surface of the head-shield in our specimen is minutely granulated, but the glabella and neck-ring possess also numerous minute inconspicuous tubercles, regularly distributed over the surface. Salter's figures show the head-shield as coarsely tuberculated, though he expressly states that it is "granular and not tubercular." His figured specimen (*op. cit.*, pl. iv, figs. 5, 6) and other specimens named by him show numerous small low tubercles; so that the description is misleading.

Of other species resembling this British form the one named *Ch. maxima*, Schmidt,[1] may be mentioned; the shape of the glabella and first lateral lobes agrees closely in some specimens, and the proportions as given by Schmidt are similar; but the presence of distinct second lateral lobes, the more numerous lenses in the eye, and the absence of a tubercular ornamentation mark it off.

Dimensions.

	mm.
Length of head-shield	19·0
Width of head-shield...	50·0
Length of glabella	15·0
Width of glabella (anterior end)	25·5
Width of glabella (at base)	12·0
Length of frontal lobe	11·0

Phacops (Chasmops) macroura (Sjögren)? (Pl. XII, Fig. 3.)

The second example of the subgenus *Chasmops* is a specimen of an imperfect pygidium from the Sholeshook Limestone of the Sholeshook Railway cutting. It shows the typical characters of the form attributed by Salter[2] to *Ch. macroura*, Sjögren, but which is believed by Schmidt[3] to belong to *Ch. Eichwaldi*, Schmidt. It appears to me highly probable that the English form is distinct from both these species, and perhaps more than one species has been included by Salter and others under this name. But the species of this subgenus are so closely allied to each other that when dealing with imperfect and fragmentary specimens it is almost impossible to separate them with certainty.

In this Sholeshook specimen there is a faint row of pits visible along each pleural furrow on the lateral lobes, such as was described by McCoy[4] in the pygidium of *Ch. macroura*, but this feature was not mentioned by Salter in his specific description and is not observable in the majority of British specimens, though perhaps

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 112, pl. iii, fig. 11; pl. iv, figs. 1–3 (especially fig. 2), etc.

[2] Salter: Mon. Brit. Trilob., p. 37, pl. iv, figs. 18–23.

[3] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 117, pl. iv, fig. 1; pl. v, figs. 8–10, 16; pl. x, fig. 21.

[4] McCoy: Syn. Brit. Pal. Foss., p. 162, pl. i G, fig. 20 (*Odontochile truncato-caudata*).

this may be due to their state of preservation. It is present in *Ch. amphora*, Salter,[1] but in other respects this species is distinct.

ENCRINURUS MULTISEGMENTATUS (Portlock). (Pl. XII, Fig. 5.)

This species was not recorded by Messrs. Marr and Roberts from the Haverfordwest area, but in the Turnbull Collection there are several well-preserved pygidia and one cranidium from the Slade Beds of Cuckoo Grove Lane.

The cranidium of this species, which was described by Portlock[2] as *Ampyx* (?) *baccatus*, has a characteristic circlet of about ten large projecting tubercles in front of the pear-shaped convex glabella, which in our specimen (a cast) shows distinct traces of two pairs of lateral lobes. The tumid fixed cheek is about half the length of the glabella, and is ornamented, like it, with large tubercles. The pygidium, upon the characters of which Portlock[3] based his species *Amphion* [*E.*] *multisegmentatus*, is of an elongated triangular shape, with a long tapering axis annulated to its tip with 24–30 rings, which are quite continuous across the axis, though between the posterior ones the intervening furrows are less deep in the middle. No tubercles are present on the axis. The lateral lobes consist of 12 simple pleuræ (8–10 only show in our specimens, which are imperfect posteriorly); the anterior ones are curved gently backwards, while the posterior ones are successively more strongly directed backwards till the last few lie almost parallel to the axis. The whole surface of the pygidium is finely granulated, and there are 1–3 large tubercles on each pleura.

DIMENSIONS.	mm.
Length of cranidium	8·5
Length of pygidium	14·0
Width of pygidium (at front end)	12·5

REMARKS.—A form under the same specific name, comparable or identical with Portlock's species, has been described by Schmidt[4] from the Lyckholm Beds of the Russian Baltic provinces, and by Törnquist[5] from the Leptæna Limestone. The species has also recently been recognised in the Whitehouse and Drummuck groups of the Girvan district. It is closely allied to *E. Seebachi*, Schmidt,[6] from the Wesenberg Beds.

The points of difference between *E. multisegmentatus* and the allied *E. multiplicatus* have been previously given by the present author[7] in describing the latter. The type of Portlock's *E. multisegmentatus* is in the Jermyn Street Museum, where I have had the privilege of examining it.

[1] Salter: op. cit., p. 42, pl. iv, fig. 16.
[2] Portlock: Geol. Rep. Londonderry, p. 262, pl. iii, fig. 11.
[3] Ibid., p. 291, pl. iii, fig. 6.
[4] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. i (1881), p. 227, pl. xiv, figs. 14, 15; pl. xv, figs. 19, 20.
[5] Tornquist: Undersökn. Siljansom. Trilobitf. (Sver. Geol. Undersökn., ser. C, No. 66), 1884, p. 24, pl. i, figs. 18, 19.
[6] Schmidt: op. cit., p. 229, pl. xiv, figs. 16–26; pl. xiv, figs. 21–23.
[7] Reed: GEOL. MAG., Dec. IV, Vol. VIII (1901), p. 107, Pl. VII, Fig. 3.

EXPLANATION OF PLATE XII.

Fig. 1.—*Phacops* (*Chasmops*) *conicophthalmus*, Boeck. Head-shield. Slade Beds, Upper Slade, Haverfordwest. × 1½.
,, 2.—*Phacops* (*Dalmanites*) *socialis*, Barr. Var. Nearly complete individual. *Orthis argentea* zone, Prendergast Lane, Haverfordwest. Nat. size.
,, 3.—*Phacops* (*Chasmops*) *macroura*, Sjögr.? Portion of pygidium. Sholeshook Limestone, Sholeshook Railway Cutting, Haverfordwest. Nat. size.
,, 4.—*Phacops* (*Dalmanites*) aff. *incertus*, Desl. Pygidium. Slade Beds, Upper Slade, Haverfordwest. × 2½.
,, 5.—*Encrinurus multisegmentatus*, Portl. Pygidium. Slade Beds, Cuckoo Grove Lane, Haverfordwest. × 2½.

II.—Some Eroded Rocks in Corsica.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(PLATE XIII.)

As I have recently seen certain cases of the curious hollowing out of rocks in Corsica, described by Mr. F. F. Tuckett (with a note from myself) in the January number of this Magazine, for which Mr. Lake suggested an explanation in the following number, I will add something to that note and intimate why I did not refer to desert regions for an explanation. The case which Mr. Lake mentions ("Das Gesetz der Wüstenbildung," fig. 7) undoubtedly much resembles Mr. Tuckett's photographs, and so, to some extent, do figs. 16 and 17, more especially the latter. With these I was not then acquainted, perhaps having overlooked the book, because I wrote a notice of "Die Denudation in der Wüste," when it appeared in 1891, and had formed the opinion that the author was disposed to work his hypothesis for rather more than it would stand. As, however, I knew there would shortly be a chance of my getting a glimpse of the Egyptian desert, I postponed stating why I had not suggested that kind of atmospheric erosion. In this region, however, I saw no more than I already knew, but on our return, owing to an unexpected change of plans, we spent an afternoon and part of the next day in harbour at Ajaccio, when, by a lucky chance, I hit upon some curious instances of erosion, which I think may be worth a brief description.

After strolling through the town, I walked from the Place Bonaparte to a quarry which has been opened at the foot of the hills. These rise rather steeply from the town, and must be sloping just at this point roughly to the south-east. The rock was a fairly coarse porphyritic granite, grey with a tinge of pink, with the surface but slightly decomposed.[1] I rambled up the slope, on which outcrops of granite are often frequent, attracted by the beauty of the wild-flowers, until I reached a road running along the hillside,

[1] A thin slice shows the rock to be, for a granite, in good preservation. Enough to say that it consists (apart from minor details) of quartz, biotite, and felspars, some of which (probably orthoclase), by enclosing smaller crystals of another species (usually a plagioclase), and by a peculiar mottling and streaking (perhaps a result of strain), recall the felspars of one or two Alpine granites, such as the protogine of the Mont Blanc range or that on the upper part of the St. Gotthard Pass.

perhaps 400 feet above the sea.[1] Along this I strolled for a short distance to enjoy a yet wider view; the slope rising rather steeply on one hand, occupied partly with tillage, partly with trees, but showing here and there a small knoll or boulder of granite, and descending on the other hand, being overgrown, in the immediate neighbourhood, with herbage and trees.[2] On this slope, and a short distance below the road, my eye was attracted by a block of granite, apparently a boulder several cubic yards in volume, on the lower part of which was a curious excavation.

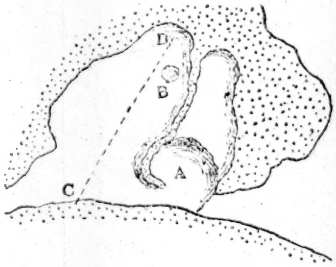


FIG. 1.—Hollow in Granitic block, outer surface dotted. A, mouth of inner hollow; B, hole into it.

FIG. 2.—Section along the line C–D in Fig. 1.

The annexed sketches (Figs. 1 and 2), though very rough, for the subject was difficult to draw, will save a long description. The hollow (as the section in Fig. 2 shows) was on rather the under side of the boulder, against which a smaller one was lying. From C to D (Fig. 1) was about 30 inches (estimate), and the deepest part (at A) perhaps 16 inches. From this, however, a funnel-like cavity went upwards with a circular opening into it at B, about 2 inches in diameter. Holding the head of my hammer, I thrust the handle up the funnel till its end passed this opening. How much higher it may go I cannot say, for when I have a defective knowledge of the aggressive fauna of a country I am not over curious in exploring dark hollows. The part drawn looked roughly west, and on the opposite side of the block was a smaller hollow.

A few yards lower down the slope a block of granite, measuring rather more than a yard one way and a little less the other, is built into a low wall. On its surface are no less than eleven basin-like hollows, most of them about 4 inches in diameter; two being from 8 to 10 inches deep, and others 4 or 5 inches. As I scrambled downwards through the wood I saw many more hollows, either in boulders or in outcrops of granite, sometimes one, sometimes several on a block. Some were mere 'potholes' like those made by water, others short channels, rudely resembling the cast of a slug, which not seldom deepen in one part to a kind of basin;

[1] Perhaps it was part of the Salario Road. I had no map of Ajaccio.

[2] The majority were wild olives, as Sir W. T. Thiselton-Dyer, after examining a specimen, has kindly informed me.

others again sink deep into the stone, certain of them running either upwards or sideways; occasionally they reminded one, though of course they were much larger, of the borings made in limestone by snails.[1] One resembled those photographed by Mr. Tuckett (except that the eroded hollow was higher up the side of the block), and I think a big lad might have curled himself up inside. The surface of the blocks was in fair preservation, for though the felspar was rather dulled and whitened it was not at all rotten;[2] that of the hollows was smoothed, occasionally almost glazed, but the porphyritic felspar-crystals were often just prominent enough to catch the eye and be felt by the finger. The majority of the hollows looked towards the west; the remainder faced to the other points of the compass, sometimes more than one way on the same block, and they were at various heights from the ground. The group represented in Pl. XIII, though not one of those which I saw, gives an excellent idea of some of the hollows. I am indebted for it to Sir C. W. Wilson, K.C.B., F.R.S., to whom I had mentioned the discovery, and from whom I received it after this paper was in type. He tells me that it was on the slope, a few yards from a wall boundary and pathway, and, as far as he can remember, within a hundred yards of the garden wall of the Hôtel Continental (in the Boulevard Grandval). The dimensions are, at a rough estimate, 5 × 6 feet.

I saw from the vessel some granite blocks on the northern slopes of a valley which comes down to the sea a little to the north of Ajaccio, so I walked there next morning. They are not far from the Pénitencier de Castelluccio. Here, however, the blocks were not so numerous or accessible, and I found but one good example of these hollows, of which a diagram is annexed (Fig. 3); this occurs

Fig. 3.

on the front face of a rudely quadrangular block, defined by rough joints, which rises to a height of 9 or 10 feet above the ground, being perhaps 5 feet wide near the top. In form the hollow slightly resembles the outstretched head of a duck with a rather

[1] See Geol. Mag., 1869, Pl. XVII, and the Fig. on p. 486.

[2] In a specimen obtained from a block on a more exposed part of the hillside, in which was one hollow, the cleavage-planes of the larger felspars still reflect light fairly well.

Eroded Granite Boulder, near Ajaccio, Corsica.

From a photograph by Sir C. W. Wilson, K.C.B., etc.

pointed bill; it was about a yard long, 16 inches in greatest breadth, and 14 inches in greatest depth, the lowest point being about 7½ feet from the ground. All the figures are estimates, the hollow being inaccessible. In it were two basins, one in the head (the deeper, I think), the other at the end of the 'neck.' This face of the rock looked a little south of east.

Since my return to England I have ascertained that an account of these curious hollows was published in 1882 by Prof. H. H. Reusch (Bull. Soc. Géol. France, sér. III, t. xi, p. 53).[1] He states that they occur in both granite and schists, the smaller being called *tafoni*, the larger *grottes*, and thinks they indicate soft places in the mass, thus being the converse of the weathered out blocks which simulate erratics. He remarks that he has seen some approach to the structure in the old sea caves of Norway. They are also mentioned, with other cases of peculiar erosion, in Professor Penck's "Morphologie der Erdoberfläche" (1894, pt. i, pp. 214–216), and by him attributed to local decomposition, but these in several cases appear to be only basins of the 'sacrificial' type. Signor Paul Choffat, however, gives an excellent description of some examples in Portugal ("Communicações da Direcção dos Trabalhos Geologicos de Portugal," t. iii, p. 17) with four good illustrations. They occur in a porphyritic granite at two localities very different in situation. One, in the Gerez, is nearly 15 leagues inland on barren hills, almost 3,000 feet above sea-level; the other, at Faro d'Anha, at heights of from 500 to 550 feet in a thick wood of tall pines. There are three types: simple basins, basins with a linear arrangement and more or less in communication by destruction of the intervening walls, and, thirdly (only at Faro d'Anha), varied forms, such as I have described above, one of them being undercut, though to a less extent than that figured by Mr. Tuckett; the sides, not in this case only, exhibit a slight, rudely horizontal ridging, with an approach to a glaze. Signor Choffat attributes these hollows to local decomposition, though, if I rightly understand him, he would not exclude the possibility of some having been 'touched up' by prehistoric man. He states that the basins (of the Dartmoor type) are not unfrequently surrounded by a slight rim, as if the adjacent rock were slightly harder than the rest, mentioning a suggestion by Professor Heim that this might be due to percolation of silica liberated by decomposition of the felspar—an ingenious idea, worth careful consideration, for it would also explain the occasional approach to a glazing of the surface, but not quite free from difficulty, for this percolation would have sometimes to extend almost against gravitation, and one would expect the hardening of the silica to check the enlargement of the cavity.

Decomposition seems the natural explanation, but in some of the cases described this must have acted in a singularly selective way; the granite also, as I have said, shows no sign of anything

[1] I was set on the track of this and other references by Sir A. Geikie's valuable "Text Book" (p. 456). Professor Reusch also published in a Christiania scientific periodical (1878), but I have not been able to consult the paper.

like rottenness, and the schist, as implied on p. 12, is in good condition close to the very outside. The state of the surface suggests that mechanical forces may have co-operated with chemical, for it is not unlike that produced by blown sand; yet to gouge out some of these, for instance that first described, the winds would have to eddy in a very queer fashion, for the holes occasionally run deep into the rock both sideways and upwards. Nor does the action of dew or of moisture in any form seem a promising explanation, for they occur on both sheltered and exposed sides of the blocks and look to all points of the compass, though more commonly westwards.

This brings me to the difficulty, which, owing to my general knowledge of Corsica and Mr. Tuckett's descriptions, had prevented me from seeking an explanation in Indian or any other desert regions. Its scenery, so far as I know it, is at least as luxuriant as that around the subalpine Italian lakes. There was not a trace of grit or sand about the Ajaccio blocks, and to reduce an island in this part of the Mediterranean to the conditions of a desert or steppe would demand changes of geography or climate which are almost startling, and we must also suppose that since the arid epoch ended the surfaces of the hollows have undergone little or no alteration. Neither atmospheric corrosion nor any form of wind abrasion seems to satisfy all the conditions of the problem, and until I can spend some time in Corsica to study other examples I prefer to restrict myself to this statement, negative though it be.

III.—On the Homotaxial Equivalents of the Lower Culm of North Devonshire.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

In the paper on the Pendleside group at Pendle Hill, Q.J.G.S., vol. lvii, p. 377, I said, "The further facts of the distribution of *Glyphioceras spirale* and *Posidonomya Becheri* set forth in the foregoing pages open up the wide question of the age of the Culm beds of Devon and Germany." Since then I have had the great advantage of examining suites of fossils from the Lower Culm of Devonshire, collected by Mr. Hamling, of Barnstaple, and Mr. Coomáraswámy, from the Coddon Hill Beds and other localities in North Devon. I was so interested in the fossils that I found it necessary to go down and examine the beds in which they occurred, and Mr. Hamling gave me the inestimable advantage of his guidance. In this way we examined the Lower Culm and the underlying Pilton Beds in detail from West Leigh to Fremington, and the so-called Middle Culm of Bideford and other places. I was able to see the Hall collection of fossils at Barnstaple, and again to renew my acquaintance with Mr. Hamling's collection. This visit to Devonshire, it seems to me, was fortunately planned after a visit last Summer to the Devono-Carboniferous succession in the south-west of Ireland, and a study of the fauna in the collection of the Geological Survey at Dublin and in the Museum of Queen's College, Cork.

If palæontology is of any value, and the distribution of fossils does indicate homotaxis, then we are particularly fortunate in the Culm, which, though it is not richly fossiliferous, yet contains peculiar and well-marked species, which do indicate well-marked horizons in the Carboniferous series further north.

There are certain stratigraphical facts which are well known, such as the general succession of the Devonian series and its relation to the Culm. It is agreed that the geological structure of Devonshire is a synclinal, and that in the north the rocks are all very highly tilted and dip steadily south at high angles; that the dip is not simple, but that in each member of the series there are many secondary folds, owing to which it is impossible to estimate the thickness of each division. There appears to be no unconformity between the Upper Devonian or Pilton Beds and the Lower Culm.

The Lower Culm consists of two very distinct series of rocks: the Coddon Hill Beds, which are composed of thin-bedded, hard, siliceous, or cherty, light-grey or fawn-coloured rocks, full of radiolarian remains, and containing a small but distinctive fauna, and the Venn or Black limestones, of hard, splintery, black, semi-crystalline limestone and calcareous shales with *Posidonomya Becheri* and *Glyphioceras crenistria*.

The first and important point to settle is the true succession in the Lower Culm, that is to say, what is the relation between the peculiar thin siliceous beds of Coddon Hill and the Black limestones yielding *Posidonomya Becheri* of Venn, Bampton, and West Leigh?

Sedgwick (Trans. Geol. Soc., ser. vi, vol. v, p. 670) thought that the Coddon Hill Beds were below the *Posidonomya* beds. Phillips and many others thought the reverse; but Mr. Ussher ("Culm-measure Types of Great Britain," Trans. Inst. Min. Engineers, vol. xx, 1901, p. 362), in his table of the classification of strata, favours the view that the Coddon Hill cherts are below the *Posidonomya* beds. This Mr. Hamling tells me has been his opinion, and together we examined the ground carefully with a view to ascertain the evidence for this succession.

Mr. Hamling writes me as follows:—"I see at the reading of Hinde & Fox's paper on 'A well-marked horizon of Radiolarian Rocks in the Lower Culm of Devon, etc.,' I expressed agreement with their conclusions, which suggest that Venn beds are below Coddon Hill (Q.J.G.S., vol. li, 1895, p. 609). I have worked these beds very closely since then, and now believe the Coddon beds are below Venn. Perhaps you can explain this change of opinion since 1895."

Standing on Coddon Hill and looking north and east, it is to be noted that the Coddon Hill range runs east to beyond the village of Swimbridge, and that it meets east of that village a ridge which runs into it from the west, forming a Y; i.e., there is a synclinal of Coddon Hill Beds which west of Swimbridge has the beds contained in the syncline gradually pinched out in succession, so that the two limbs of the synclinal come together. The contour of the surface of

the synclinal trough is important. Tracing the rocks from north to south, Coddon Hill beds form an east to west line of elevation, succeeded by a hollow trough. In this hollow the Venn limestones,

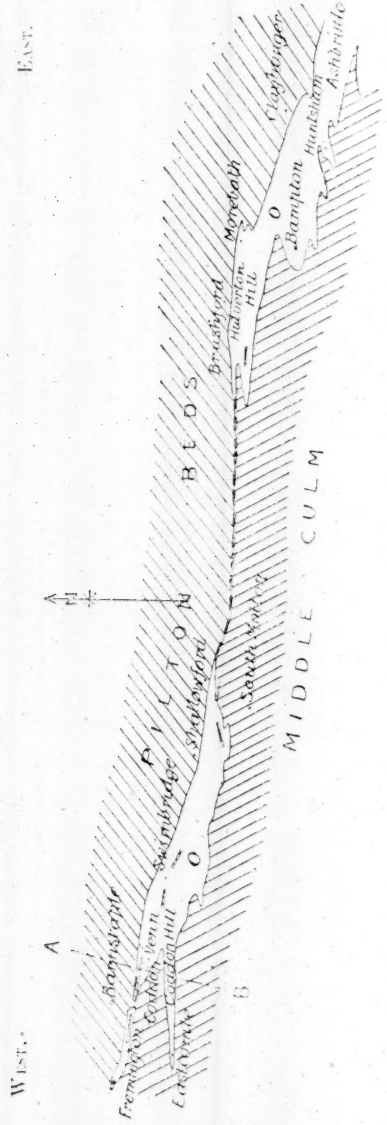


Fig. 1.—Country near Barnstaple, from Fremington and Eastcombe on the West to Clayhanger and Ashbrittle on the East.
O, O = the Coddon Hill Beds, with *Posidonomya* Limestone; A-B, line of section given in Fig. 2.
Scale, 6 miles to an inch.

with *Posidonomya Becheri*, have been worked. In the centre of the synclinal is an east to west line of elevation, sections of which

show grits and rocks of a Middle Culm type. South there is a hollow parallel with the strike between these grits, the main Coddon Hill range, which I think indicates the Black limestone of Venn, and immediately south is the Coddon Hill range. This would make the succession—

Middle Culm grits.
Posidonomya beds.
Coddon Hill beds.

Unfortunately no limestones have been worked in the hollow south of the Middle Culm, although the depression which exists parallel to and between the Coddon Hill Beds and Middle Culm grits seems to indicate calcareous beds.

There is no doubt that the dips taken in various quarries show that the beds on the north are dipping south, and those of the main Coddon Hill range dip north. Also the Venn limestones are dipping south at a very high angle, conformable to the Coddon Hill Beds of Venn Cross quarry on the north side of the synclinal. So that in the valley between Venn Cross, where the beds dip south, and Coddon Hill, where the beds dip north, is situated the Venn limestone with *Posidonomya Becheri* and the Middle Culm grits. Traced east, in the gradually vanishing synclinal, first of all the feature formed by the Middle Culm grits disappears near Hannaford, and in the hollow between this terminating feature and the junction of the two limbs of the Coddon Beds, the *Posidonomya* limestones crop out rich in fossils and occupying a hollow with beds of Coddon Hill type to the north and south of it.

East of Swimbridge, from Filleigh to Marsh, are a line of old workings in the Black limestones, but the Coddon Hill Beds become faulted out, so that apparently in turn, first *Posidonomya* beds and then the Middle Culm beds rest on the Pilton series or Upper Devonian. At Headon, quarries of well-marked Coddon Hill Beds, here associated with much wavellite, are dipping south and are north of the line of the Filleigh limestones, but a little east of North Aller Farm they have disappeared and the limestones are faulted against Pilton Beds. For the next 17 miles eastward Lower Culm beds have been cut off by faults, but near Dulverton Station beds of Coddon Hill type are to be seen having the same strike as at Coddon Hill east and west, dipping almost vertically but with a southerly trend.

Close to Dulverton Station, near Brushford village, is a quarry in Pilton Beds whence Phillips obtained many of the fossils which he described, and south of this village is Kent's Hill quarry with thin siliceous beds of the Coddon Hill type. About half a mile further east is the Hulverton Hill quarry. This hill has the curious contour which seems to be typical of Coddon Hill Beds elsewhere, and the beds themselves are characteristic. Nowhere are beds of *Posidonomya* limestone seen between Pilton and Coddon Hill Beds. Still further east, at Ashbrittle, are Coddon Hill Beds, and these are apparently lying on Pilton Beds.

If the geological map made by Mr. Ussher and published in his paper in the Transactions of the Institute of Mining Engineers (op. supra cit.) be examined, it will be seen that from south to north the Lower Culm beds tend to form a succession of small evanescent synclinals due to folding. Tongues of Middle Culm measures invade the Lower Culm, lying in small troughs which become lost as they pass east. One of these troughs runs up between Hulverton Hill and Westbrook, but in this trough I think I am right in saying no limestones have been found. But at Westbrook Farm and near the road from Brushford to Bampton, beds of Coddon Hill type are to be seen dipping south, to pass beneath the *Posidonomya* limestones so fully exposed in the many Bampton quarries. In the railway cutting north of Bampton Station the beds are distinctly thin and cherty, and approach closely to the Coddon Hill type.

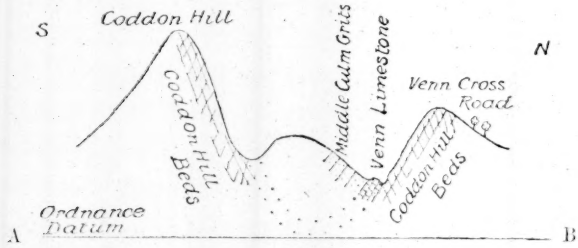


Fig. 2.—Section through Coddon Hill Beds, Barnstaple, on the line A–B in Fig. 1. Scale: horizontal, 4 inches = 3 miles, or 2 inches = 1½ miles; vertical, ¼ inch = 150 feet.

At Holcombe-rogus and Westleigh the well-developed limestones all crop out south of the general strike of the Coddon Hill Beds, but the time was too short, in this immediate neighbourhood, to examine the ground in sufficient detail.

West of Barnstaple an examination of the succession at Fremington seems to point to similar conclusions. The river bank at Fremington shows a series of fossiliferous shales with numerous Brachiopods and corals of a Carboniferous type, but containing no fossils which could be used as an index of horizon. These beds evidently are either at the top of the Pilton series or immediately overlie that series, but for our present purpose it is important to note the relation of the strike of these beds to that of the Pilton series, for they afford a base-line for the determination of the beds immediately above them. These are seen at Pen Hill quarry, immediately south of the railway line, where there are thin platy beds with cherts in bands and siliceous beds, but also there is here a development of calcareous beds of some few feet in thickness. The limestones and shales, however, have not been found to contain *Posidonomya Becheri*, and the whole section bears a close lithological resemblance to the Coddon Hill Beds. The beds are dipping south at an angle of 28°. At Fremington Pill, near Gaydon's Cottage, thin-bedded

siliceous rocks of light fawn colour, with numerous chert bands, here decomposed, strongly recall Coddon Hill Beds. These lie above the beds seen in Pen Hill quarry, and in the upper portion of them, 90 yards from the wall of Gaydon's Cottage, occurs *Posidonomya Becheri* in abundance. A short distance further south the Black *Posidonomya* limestones have been worked.

On the foreshore west of Fremington Station are beds dipping 50° S. which have a Coddon Hill character: they are apparently on the top of the limestone band in Pen Hill quarry, which crops out on the shore at low water. This would make the succession at Fremington as follows:—

Posidonomya Becheri Limestones	Venn Limestones.
Dark shales with *P. Becheri*.	
Lighter-coloured shales with cherts	Coddon Hill Beds.
Band of limestone	
Shales	
Fossiliferous shales	Passage beds.
Pilton series	Upper Devonian.

Following the beds along the strike westward, no beds of Coddon Hill type are to be seen between the Fremington limestones and the Middle Culm beds at Instow.

The beds at Instow are of great importance; they consist of a series of sandstones, shales, and clays, including calcareous nodules crammed with fossils. I was fortunate enough to find two species which had not previously been recorded from these beds.

Pterinopecten papyraceus, Sow., sp.
Posidoniella lævis, Brown, sp.
Gastrioceras Listeri, Martin, sp.
Gastrioceras carbonarium, V. Buch., sp.
Dimorphoceras Gilbertsoni, Phill., sp.
Coelacanthus elegans.
Elonichthys Aitkeni.

These beds seem to succeed the sandstones and shales at the base of the Middle Culm, and the fauna indicates unmistakably the Lower Coal-measures of the horizon of the Bullion Mine of Lancashire.

Quarries between Instow and Bideford show indurated clays, shales, and grits, which have a very familiar aspect to anyone well acquainted with the Coal-measures of the Midlands.

Roberts' Quarry, east of Bideford, is an important horizon, because here in indurated clay and fawn-coloured shales abundant plant-remains occur, which are identical with ferns and plants found in the Coal-measures of the Midlands. Immediately above the plant-bed is an indurated light-coloured clay, with iron stains in its joints, in which the typical Coal-measure shell *Carbonicola acuta* is not uncommon. Unfortunately, time did not allow further work in the beds above the Lower Culm, but the fauna and flora bear out Sedgwick's view (op. supra cit., p. 682), "The Upper Culm strata of Devon are the geological equivalents of the ordinary Bristol coalfields."

Palæontology. — The fossils of the Lower Culm are, with the exception of some new species of Trilobites described by Dr. Henry Woodward, not confined to Devonshire, but are known to have a fairly definite and constant distribution in other Carboniferous areas.

In that area of England between Cracoe in Craven and Leicestershire where the Pendleside series is developed, it is found that immediately on the top of the massif of Carboniferous Limestone at Warsoe, at the foot of Pendle Hill, in the River Hodder, near Stoneyhurst, and at Astbury limestone quarry at the foot of Congleton Edge, Cheshire, are beds containing *Prolecanites compressus* and Trilobites of various species. Higher up in the series are beds with *Posidonomya Becheri*. Then at Congleton Edge and Pendle Hill some 300 feet below the Millstone Grit beds are marine shales with *Glyphioceras spirale*. Such a succession has been found to occur in many localities, and I take it to be a normal one, and that the fossils mentioned above indicate definite zones in the Pendleside series. Seeing that these fossils occur in the Lower Culm series, it is important to ascertain whether there is any stratigraphical reason for supposing a different succession of these fossil zones; if not, the known relation of the fossil zones in other areas may be used as an argument for a similar succession in the Culm area.

In the Lower Culm series there are two distinct faunas, one contained in the Coddon Hill Beds, the other characterising the Venn limestones.

Beds of Coddon Hill type.

In the Coddon Hill Beds the following important fossils have been obtained:—

Trilobites.

Phillipsia Levi.
,, *minor.*
,, *Cliffordi.*
? **Phillipsia Pulleni.*
Griffithides acanthiceps.
,, *longispinus.*
Proetus, sp.

Corals.

**Palæacis humilis*, Hinde.
**Pleurodictyum Decheni anum*, Kayser.
**Petraia* cf. *pauciradialis*, Phill.

Cephalopoda.

Prolecanites mixolobus, Phill., sp.
* ,, *compressus*, Sow., sp.
**Nomismoceras spirorbis*, Phill., sp.
**Pericyclus*, sp.

Lamellibranchs.

**Chanocardiola Footii*, Baily, sp.

Brachiopoda.

**Chonetes Laguessiana*, and shells either crushed or varieties alluded to by Von Koenen as *C. deflexa* and *C. rectispina*. **Productus plicatus*, Sarres.

*Several Radiolaria.

The species marked * are all found at the base of the Pendleside series in the Bolland district of Yorkshire. The exact locality where Phillips obtained *P. mixolobus* is unknown, as he only gives Bolland, which is a large district in which are beds belonging to the Carboniferous Limestone, Pendleside series, and Millstone Grit.

Palæacis humilis, says Dr. G. J. Hinde, is "fairly common in shale or mudstone, associated with limestones and chert exposed on the banks of the river Hodder, below Stoneyhurst College, Lancashire; according to Mr. R. H. Tiddeman the rocks . . . . come in between the Clitheroe limestones and the Pendleside limestones."

This is so, the beds forming the base of the Pendleside series. It occurs in the Lower Culm only in beds of the Coddon Hill type.

Chænocardiola Footii is a shell always associated with a lower Pendleside fauna in the Midlands and Ireland; its occurrence in the Lower Culm of Hannaford quarry is important. Mr. J. G. Hamling has some fragments in his collection, but I was particularly fortunate to find two valves in the trilobite beds of Hannaford quarry. In my monograph on British Carboniferous Lamellibranchs, vol. i, p. 476, I quoted Coal-measures as the horizon for this species. I think Roscliff, co. Clare, is below that horizon, and should be Pendleside series.

Prolecanites compressus.—Although I feel strongly the value of this species as a zonal form, there is no doubt that it is not absolutely confined to the base of the Pendleside series, for it occurs in the Carboniferous Limestone of Little Island, co. Cork, and in the lower limestones of Scarlett Quarry, Isle of Man. Still, there is a definite and well-defined series of rocks, of no very great thickness, immediately at the base of the Pendleside series, which is characterised by this shell, and it does occur below shales and black limestones with *Posidonomya Becheri*.

Nomismoceras spirorbis.—The type of this species was obtained from the Black limestone of Black Hall, Bolland, Pendleside series; and it is of great interest to note that the strike of the beds and their relation to the Millstone Grits at Black Hall would make these beds below a series quarried at Cold Coates which contain *P. Becheri* in abundance.

Pericyclus, sp.—I have obtained similar examples from the Pendleside series of Yorkshire and the Lower Culm.

Trilobites.—Dr. H. Woodward described two Trilobites from the base of the Pendleside series (R. Hodder, Geol. Mag., 1894, Dec. IV, Vol. I, pp. 481–489), *Phillipsia Polleni* and *P. Van-der-Grachtii*. Subsequently I found the latter associated with *Prolecanites compressus* at Ashbury quarry, Cheshire, and Dr. H. Woodward recognises *P. Polleni*, though with some hesitation, in the cherty beds of Coddon Hill (Geol. Mag., 1902, Dec. IV, Vol. IX, p. 482). It is important, however, to note the occurrence of species of Trilobites at the horizon of the base of the Pendleside series and Lower Culm, the majority of which do not occur in the Carboniferous Limestone.

Brachiopoda.—There is no very important evidence afforded by the Brachiopoda found in the Lower Culm and Pendleside series. I have always regarded the varieties of *Chonetes* occurring in the Culm of Germany and described under different names to show no greater difference from each other than is found to obtain amongst a number of individuals collected from the same bed and horizon. Certain species of *Productus* may be peculiar, but unfortunately the specimens are not well enough preserved to say whether the differences are due to dwarfing and crushing or to specific characters. All the other Brachiopods, *Discina nitida*, *Leptæna analoga*, *Orthotetes crenistria*, *Athyris ambigua*, occur at many horizons in the whole Carboniferous series.

Radiolarian rocks also are found in the Pendleside series. There is, therefore, a very remarkable and close resemblance in the faunas of the Coddon Hill Beds of the Lower Culm and the Pendleside series: so practically identical, indeed, are they, that there can be little or no doubt that they are the homotaxial equivalents of each other.

The Venn, or *Posidonomya Becheri* Limestone.

The fauna contained in the black limestones of North Devon is not so rich in species as that of the Coddon Hill Beds, but the following species are abundant:—

Posidonomya Becheri.
Pseudamusium fibrillosum.
Glyphioceras spirale.
,, *crenistria.*
Glyphioceras striatum.
,, *sphæricum.*
Orthoceras cylindraceum.

Plant Remains: *Cordaites*, sp.

Posidonomya Becheri.—I only recognise one species. The examination of a large number of specimens has convinced me that the forms *P. tuberculata* and *P. lateralis* are accidental, due to conditions of preservation and degree of flattening by compression.

I regard *P. Becheri* as an important zonal form, indicating a horizon somewhat above that of *P. compressus*. I have found this zone constant in position from Old Head of Kinsale in the south of Ireland to Clavier and Visé in Belgium. The zone has no great vertical depth, and I am unable to indicate the precise thickness, but in the Midlands, beds characterised by *G. spirale* extend some hundreds of feet above *P. Becheri*.

I have, as in the case of *Prolecanites compressus*, found specimens of *P. Becheri* at a lower horizon. It occurs in the Yoredale series of Wensleydale above the Great Scar Limestone, and I have found it actually in the top beds of the Carboniferous Limestone at Castleton, but in these places it has, with it, a typically Carboniferous Limestone fauna.

At Poolvash, Isle of Man, *P. Becheri* occurs in black limestone and shales, which succeed the shelly white upper beds of the Carboniferous Limestone. With it is the following fauna:—

Solenomya costellata.
Orthoceras Morrisianum.
,, *sulcatum.*
Glyphioceras crenistria, and a crushed Cephalopod which Mr. Crick identifies as *Stroboceras sulcatum.*

I have not been able to get at the beds at the base of the series, where I should expect to find *Prolecanites compressus* and Trilobites.

Some curious beds containing *P. Becheri* occur at Budle, Northumberland, the real horizon of which is very doubtful and vague.

Ireland.

In co. Dublin the Pendleside series succeeds the Carboniferous Limestone near Sherries; at the former horizon *P. Becheri* is found in abundance. At Old Head of Kinsale, south-west of Cork, *P. Becheri* occurs in hard shaly beds in a curious sequence of shales and thin indurated calcareous beds. In South-West Cork, as in Devonshire, the Carboniferous Limestone is absent, and there is

a passage from Devonian rocks into Carboniferous without a stratigraphical break. Curiously enough, beds with a Devonian fauna, *Cucullæa unilateralis* and *Ptychopteria Damnoniensis*, which in Devonshire are recognised as the *Cucullæa* beds and occur below the Pilton Beds, are classed as Carboniferous in Ireland. It appears to me that a similar sequence occurs in both South-West Cork and Kerry and Devonshire. The Coomhola grits with *Cucullæa unilateralis* and *Ptychopteria Damnoniensis*, are the equivalents of the Pickwell Down and Baggy Point Beds, and the beds with *P. Becheri*, the equivalents of the Venn Limestone series of the Lower Culm. It would be well if stratigraphical lines, based on palæontology, were identical in the two countries. The fauna of the Coomhola grits is typically Devonian, and not Carboniferous. The absence of Carboniferous Limestone in North Devonshire and further west along the line of strike, at Old Head of Kinsale and the part of Ireland west of that point, shows that this absence in both localities is due to the same conditions of deposit. The succession in both countries is the same.

Devonshire.	South-West Ireland.
Lower Culm	*Posidonomya* beds, Pendleside series.
Pilton Beds	Coomhola grits } Upper Devonian.
Baggy Beds	*Cucullæa* zone }

The absence of Carboniferous Limestone in both areas is very definite, and the recognition that the sequence in North Devon and South-West Ireland is identically the same not only broadens the question, but at the same time demonstrates that the Culm of Devonshire is not merely a local condition, and that the absence of Carboniferous Limestone in South-West Cork and in the Carboniferous series of Devonshire is due to the same series of causes.

Pseudamusium fibrillosum.—This species is, as far as I know, never found below the Pendleside series, but it passes up into Coal-measures. This is an important species, because it has been obtained from the Culm of Herborn and Magdeburg. For the synonymy of this species *vide* my monograph on British Carboniferous Lamellibranchs, vol. ii, p. 106.

Glyphioceras spirale.—This species is very plentiful, occurring in thousands, in a blackish shale about 500 feet below the third grit at Congleton Edge, Cheshire. I have found it at various other localities in Yorkshire, but I always consider that it denotes a zone higher up in the series than that of *P. Becheri*. The species appears to be more common in South Devonshire than in the north of the country, and I can say nothing definitely about its actual position in the series there, but it is stated that it occurs with *Posidonomya*, Ussher, "British Culm Measures," Somerset Arch. and Nat. Hist. Soc., vol. xxxviii (1892), p. 132; he says, "The *Posidonomya* in these beds are, as a rule, smaller than those occurring in the beds which in the Chudleigh and Bovey Tracey districts carry on the calcareous horizon." In Cheshire *G. spirale* occurs with *Posidoniella lævis*. The other Goniatites found in the *Becheri* beds are not typical of the horizon, for they occur at various horizons in the Carboniferous

Limestone series, but are specially plentiful in the upper shelly limestone of Derbyshire, Staffordshire, and Yorkshire.

Palæontological evidence is therefore decidedly strong in favour of the *Posidonomya Becheri* beds overlying the Coddon Hill Beds, especially when such a sequence of fossil zones is found to obtain over large areas at a distance.

The occurrence of flinty deposits at a definite horizon in the Carboniferous beds may be adduced for what it is worth. In Wensleydale the chert beds come on immediately on the top of the Yoredale series. In Derbyshire and Yorkshire the chert horizon is found at the base of the Pendleside series. At Bishopton, near Gower, a series of white cherty beds, containing Trilobites and Brachiopoda, occur on the top of the upper beds of the Carboniferous Limestone, the Oystermouth Beds. The cherty beds are here overlain by black shales, with *Posidoniella lævis* and *Glyphioceras bilingue*, fossils which occur low down in the Pendleside series. These cherty beds are, I believe, homotaxial with the Coddon Hill Beds. Similar cherty beds, but much less well developed, are to be seen at Clavier, near Dinant, in Belgium, where a typical lower Pendleside fauna, *Prolecanites compressus* and *Chænocardiola Footii*, etc., is obtained. The beds at Clavier rest in hollows in the Carboniferous Limestone, and are therefore on the horizon of the Pendleside series, a fact which cannot be doubted if the collection of fossils made by the Geological Survey of Belgium, and now placed in the Musée Royale at Brussels, is examined. I was enabled by the kindness of Professor Dupont, Director of that Museum, to study all the fossils collected from Clavier, and I identified the following. It was, however, impossible for me to determine in what position they occurred *in situ*, but it is doubtless on record.

Phillipsii, sp., with long cheek spines.
Pseudamusium fibrillosum.
Posidoniella lævis.
Posidonomya membranacea.
Pteronites angustatus.
Chænocardiola Footii.
Athyris ambigua.
Chonetes Laguessiana.
Productus scabriculus.
Productus semireticulatus.
Orthoceras, sp.
Prolecanites compressus.
Glyphioceras bilingue.
Glyphioceras spirale.
? *G. diadema.*
Cælonautilus sulcatus.
Lestracanthus Beyrichii.
Crinoid joints.
Plant remains.

And from shales at Visé I determined

Posidonomya Becheri.
Pterinopecten papyraceus.
Posidoniella lævis.

Whether or not the Coddon Hill Beds are below the *Posidonomya* limestones, it cannot be denied that the palæontological evidence shows that the Lower Culm is the homotaxial equivalent of the Pendleside series, and that the Instow Beds indicate Lower Coal-measures, and the *Carbonicola acuta* and plant beds near Bideford represent Coal-measures of a higher horizon. The Culm series, then, represents the whole Upper Carboniferous series of the Midlands, and in this case the idea of workable coal being found in Devonshire

is very improbable. It seems to me that the beds of Culm represent the total result of the attempt to form coal, and nothing more is to be hoped for. The views expressed in this paper are the result of a profound belief in the value of certain Carboniferous fossils as zonal indices, based on careful observation in the Midlands. The zones are not quite so well defined as those which obtain in older and newer formations, a result probably due to conditions of deposit, but nevertheless I find these life zones to be of economic importance to the mining engineer.

A paper in the Geological Magazine for June by Dr. J. H. Parkinson, pp. 272–276, on "The Zoning of the Culm in South Germany," is of interest, because from an examination of the fauna of the Culm of Königsberg he arrives at the conclusion that this Culm with a Visé Limestone fauna lies above the *Posidonomya* shales of Herborn.

This is very improbable. The Herborn fauna is identical with that which is found in the Pendleside series of England, which is definitely known to succeed beds with a Visé limestone or a *Productus giganteus* fauna. At Visé also shales with *P. Becheri* succeed the Visé Limestone, and lastly the Tournai Limestone, to which Dr. Parkinson refers the *Posidonomya* beds of Herborn, does not contain the fauna characteristic of the Lower Culm, but has an altogether different assemblage of fossils. Judging from the fauna of Königsberg Culm, I think he is quite correct in referring the beds to the Visé horizon, but beyond that I beg to join issue with his conclusions.

Through the kindness of Dr. H. Woodward I have been favoured with the précis of Mr. Newell Arber's paper on "The Fossil Flora of the Culm Measures of North-West Devon," read before the Royal Society on June 9th. This paper conclusively proves from the evidence of the flora that "the horizon in the Upper Carboniferous represented by that portion of the Upper Culm Measures in which the Coal or Culm occurs in the Bideford district is equivalent to the Middle Coal-measures in other British coalfields." That this is so I have also attempted to demonstrate by the known presence of *Carbonicola acuta* at Bideford, and a Gannister or Lower Coal-measure fauna at Instow.

I greet this work of Mr. Newell Arber with delight, because it tends to prove the subject-matter of this paper from an entirely different point of view.

IV.—Note on the Correlation of some Cornish Beds with the Gedinnian of Continental Europe.

By Uffield Green, F.G.S.

THE group of beds which I propose to identify and correlate with those known in France, Germany, and Belgium by the name of 'Gedinnien,' forming the lowest member of the Devonian system, extends in its full development from the Lizard peninsula in the west to Gorran and St. Austell on the east, and thence to near Newquay on the north. The upper beds, at least, may be traced

through Fowey and Looe along the coast, and across the Start peninsula as far as Babbacombe, south of Dartmouth in Devonshire. They are referred to by Ussher[1] as 'Dartmouth Slates.' They exist also on the north of the Devonian basin, and are mentioned by Etheridge[2] as underlying the Lower Devonian.

Reference has of course been made to them by various English authors, but few have attempted to assign to them a definite stratigraphical position, and fewer still have studied them in detail or made any investigation of the Continental equivalents occupying a similar position in the Devonian series.

Literature.

The earliest reference I can find is by Berger[3] in 1811, the next by Sedgwick[4] in 1821–2, who was followed by Conybeare[5] in 1823. In 1832 Boase[6] published an exhaustive petrological description of the district (according to the light of that time), founded on no less than 1,085 specimens deposited in the Museum of the Royal Geological Society of Cornwall, with a series of sections. He also attempted an extension of the hitherto accepted nomenclature of the components of the rocks (pp. 369–425 of his paper), which he termed 'Ocrynian.'

In 1838–40 Sedgwick and Murchison,[7] De la Beche,[8] and the Rev. D. Williams[9] made the first serious attempts at unravelling the structure of the county, while T. Weaver[10] commenced a comparison with Continental areas. Since then no comprehensive description has appeared, but isolated papers may be found in the Proc. Roy. Geol. Soc. Cornwall, Roy. Inst. Cornwall, and the Quart. Journ. Geol. Soc. London, by J. H. Collins, 1872–1903, Howard Fox, 1885–1903, and others.

Collins[11] considered the whole of the beds at the extreme south-west of the county, from Penhale to Breage, as pre-Silurian; a small strip, extending from Penhale to the Van and St. Austell, and the area south of Porthmellin and Gwennap to Mullion and Porthalla, as Lower Silurian; Newquay and Ladock and a small extent of ground on the coast to the north of Porthalla as 'Ladock beds' = Upper Silurian. For a comparison of the northern exposures in Devonshire with other areas, Sharp, Quart. Journ. Geol. Soc., ix (1853); Jukes, Quart. Journ. Geol. Soc., xxii (1866), and Additional

[1] Summary Progress Geol. Survey, 1902, pp. 160–165.
[2] Quart. Journ. Geol. Soc., xxiii (1867), p. 585.
[3] Trans. Geol. Soc., i, p. 93.
[4] Trans. Cambridge Phil. Soc., i, pp. 89, 291.
[5] Annals Phil., ser. II, v, p. 184, and vi, p. 35.
[6] Trans. Geol. Soc. Cornwall, iv, pp. 234–264.
[7] Trans. Geol. Soc., ser. II, v, p. 633.
[8] Geol. Survey.
[9] Proc. Geol. Soc., iii, pp. 115 and 158; and Phil. Mag., ser. III, xvi, pp. 59–64.
[10] Phil. Mag., ser. III, xvi, pp. 59–64.
[11] Journ. Roy. Inst. Cornwall, vii (1881), p. 37, and Trans. Roy. Geol. Soc. Cornwall, x (2), 1880, p. 51.

Notes (Dublin, 1867); Etheridge, Quart. Journ. Geol. Soc., xxiii (1867); and Hull, Geol. Mag., Dec. II, V, may be consulted.

'Gedinnien' of the Continent.

These beds have been described by many eminent geologists in their respective countries. Among them may be mentioned Gosselet and Barrois in France; Dumont, Dewalque, and Malaise in Belgium; Von Dechen, Koch, Kayser, Holzapfel, Rothpletz, and Lossen in Germany. To Professors Gosselet, Barrois, Kayser, and Holzapfel I am gratefully indebted for personal guidance and much information.

Speaking generally, the beds comprised in the Continental Gedinnien in descending order are as follows:—

1. Slates, mostly variegated and phyllitic, underlying the 'Taunusian,' with fish remains either in the base of the latter or in the slates themselves.

2. Arkose or Felspathic Grits, locally, and more especially on the south border (Taunus, etc.), sericitic and metamorphous.

3. Conglomerates with pebbles of more ancient rocks in a felspathic and quartzose matrix. These conglomerates seem to follow the sinuosities of the old coastline, and only appear intermittently in their original form, being as a rule much altered by hydrothermal action induced by pressure and folding. The latter subject has been treated at great length by Lossen.[1]

A comparison of this description with that given by Hull[2] of the Dingle and Glengariff Grits of Ireland may be of interest. He records—

1. Conglomerate.
2. Red and green grits.
3. Purple slates passing unconformably below the (? Lower) Old Red of Cork. And he suggests that the Foreland group of North Devon, of which the base is not seen, described by Jukes[3] as "thick massive grits of green and red colour, with purple slates similar to many parts of the (? Lower) Old Red of the south-west of Ireland," corresponds with these grits.

The Cornish Gedinnian.

Turning now to the Cornish beds, and commencing east at Looe, where the variegated slates of the Upper Gedinnian are in undoubted apposition to the beds referred to by Collins[4] as Upper Silurian, and by Ussher[5] inadvertently as 'Gedinnien,' but which I consider are undoubtedly Taunusian of the 'Siegener Grauwacke' facies, as evidenced by the following typical fossils found by myself and others:—

[1] Z. deutsch. Geol. Ges., 1867, 1877, 1883.
[2] Geol. Mag., Dec. II, V (1878), p. 529.
[3] Additional Notes (Dublin, 1867).
[4] Journ. Roy. Inst. Cornwall, viii (1884), p. 167.
[5] Summary of Progress Geol. Survey for 1900.

Onychia capuliformis, Koch. ? *Capulus subquadratus*, Frech.
Pleurotomaria (?) *striata*, Goldf.
Conocardium, sp.
Limoptera (?) *lepida*, Sandb.
Lodanella mira, Kays.
Orthis circularis, Sow.
Orthis personata (*hipparionyx*), Zeill.
Strophomena murchisoni, A. & V.
Strophomena explanata.
Rhynchonella liconica, v. Buch.
Rensællaria ? strigiceps, Roem.
Spirifer primævus, Stein.
Spirifer mercurii, Goss.
Stropheodonta gigas, M'Coy.
Athyris undata, Def.
Tentaculites grandis, Roem.
Nereitopsis cornubicus, Green.
Petraia.
Pleurodictyon problematicum, Goldf.

We find the Dartmouth slates referred to by Williams[1] as 'ichthyoferous killas' running along the coast to Old Mills, near Hendrasick, with cleavage planes dipping south. A fault there would seem to carry the strike of the beds north-west, and on the western side of the fault they are tilted at a very high angle, 80–85° north-west, the inclination gradually diminishing to 60–75° towards Talland (where the variegation is well seen) and Polperro, continuing on to a little west of Lantivet Bay (where the remains of Pteraspidian fishes are unusually abundant). From this point they are deflected, but have the same dip, leaving the Taunusian beds of Fowey to the south, and continue on in a north-west direction through Tywardreath and St. Austell to St. Stephens, as described by De la Beche.[2]

Until now we have only encountered the upper beds of the series, but at St. Austell Bay a complicated system of faults alluded to by De la Beche[3] has apparently caused an upcast of the country to the west, and from this point the lower beds of the series, and at some places even the subjacent older rocks, are exposed. These lower beds consist chiefly of grits varying much petrologically, but mostly felspathic. This variation in a coast deposit, which would naturally vary according to the rocks from which it is derived, is not surprising. Subsequent earth-movements, folding, and overthrust faults, well described by Hill[4] in his sketch of the Porthscatho and Falmouth beds, account in many places for the immediate contiguity and alternation of grits and slates, while during deposition sea currents must have had a great local influence.

The trend of the main northern mass of these grits is well described by A. K. Barnett,[5] who records "the occurrence of several beds of arenaceous rocks approaching a conglomerate distinct from the red and variegated sandstones and argillaceous slates associated with them." "The most western of these beds at Petervale St. Agnes, dip south with same dip at Callestock, in Chiverton Valley. Beds having same line of strike at Marhasan Voaz, Treworgan, St. Erme, Trehane Vean, Trewadra, and Cuskain, also in the railway cuttings from Venton Glidor to Tarnoweth Wood, in the road cutting between Grampound and Probus, and east from Grampound to Pentuan Cliffs. These beds have the same general

[1] Trans. Roy. Geol. Soc. Cornwall, vi (1841), p. 124.
[2] Report on Cornwall, pp. 80, 82.
[3] Report on Cornwall, p. 303.
[4] Trans. Roy. Geol. Soc. Cornwall, xii (6), 1903, p. 4 .
[5] Proc. Miners' Assoc. Devon and Cornwall, 1873, p. 93.

appearance and composition throughout their length. The constituent detritus at Ladock, Trevalsa, and Pentuan is as large as peas or nuts." De la Beche also refers to these beds[1] flanked by the slates of St. Stephens and Probus respectively north and south of them.

The main southern mass of these grits passes from Mevagissey, Gorran, Caerhayes, Portholland, north of Portlooe and Carne to Treworlas, from which point it has been traced and described by Hill[2] as Porthscatho beds, south of Falmouth by Helford to Looe Pool and Helston.

The succeeding lower beds have been described by the same author under the name of 'Veryan Beds,' and he includes in them apparently the coarse conglomerates which I consider to be the base of the Gedinnian and corresponding to the base of the Devonian system on the Continent.

The discovery of fossils of Ludlow age in the Caerhayes limestone, referred to in the GEOLOGICAL MAGAZINE for July, 1904, tends to confirm this view. The unconformity of these conglomerates with the underlying rocks would appear probable from the included fragments of similar slates and quartzites. The junction of the Gedinnian with the underlying beds seems to be in many instances accompanied by pillow-lavas, a note on which will be given by Mr. Prior later on.

V.—NOTE ON *ACTINOCAMAX*, MILLER; ITS IDENTITY WITH *ATRACTILITES*, LINK.

By G. C. CRICK, Assoc. R.S.M., F.G.S., of the British Museum (Natural History).

IN a paper entitled "Observations on Belemnites," which was communicated to the Geological Society of London in April, 1823,[3] J. S. Miller defined the genus *Belemnites* thus:—"A cephalopodous? molluscous animal provided with a fibrous spathose conical shell, divided by transverse concave septa into separate cells or chambers connected by a siphuncle; and inserted into a laminar, solid, fibrous, spathose, subconical or fusiform body extending beyond it, and forming a protecting sheath." In May of the same year Mr. Miller contributed to the same Society another paper[4] in which he instituted the genus *Actinocamax* for "spathose bodies which resemble the belemnitic guard in general appearance, but are distinguished from it by presenting, instead of the terminal cavity intended for the reception of the chambered shell, a protruding and convex base."

Miller defined the genus in the following words:—"A club-shaped spathose concretion, consisting of two nearly equal longitudinal adhering portions. Apex pointed; base a convex but obtuse cone. The whole formed of a series of enveloping fibrous

[1] Report on Cornwall, 1839, p. 83.
[2] Trans. Roy. Geol. Soc. Cornwall, xii (6), 1903, p. 406.
[3] Trans. Geol. Soc., ser. II, vol. ii, pt. 1 (1826), pp. 45–62.
[4] Ibid., pp. 63–67.

laminæ." The only species mentioned, *A. verus*, is characterized as follows:—"A club-shaped spathose semitransparent horn-coloured concretion; base convex, obtuse, conical; apex submamillar. Sides depressed towards the lower end, showing two longitudinal, towards the apex branching, impressions of blood-vessels." This was stated to be from the "Chalk, and sometimes inclosed in the flints imbedded in it," of Kent, Wiltshire, and Sussex.

Although subsequently united by some authors with the genus *Belemnitella* and by others merged in the genus *Belemnites*, *Actinocamax* is now usually employed as a distinct genus to include certain belemnites from the Chalk.

Mr. C. D. Sherborn has, however, called my attention to H. F. Link's "Beschreibung der Naturalien-Sammlung der Universität zu Rostock," of which the third part, published 25th December, 1807, is devoted to "Fossile Ueberbleibsel organischer Körper, sogenannte Versteinerungen." After defining (p. 8) the genus *Belemnites* as "a conical, internally radiate crystalline shell, within which is found another many-chambered (the alveolus),"[1] Link proceeds to describe (p. 9) a new genus *Atractilites* thus:—[2] "A spindle-shaped, internally radiate crystalline shell, without alveolus," the only species given being *A. belemniticus*, respecting which he states: "the spindle-shaped Belemnites are quoted by many authors, but often confounded and not exactly described. We possess specimens completely pointed at each end. On one there are distinct traces of a foliaceous texture, in other respects they are quite similar to the usual Belemnite. I have broken a specimen and found internally the radiate structure of the Belemnite, but absolutely no alveolus, therefore they cannot be referred to the former genus" [*Belemnites*].

From the extracts given above it is quite clear that Miller's *Actinocamax* is a synonym of Link's *Atractilites*. Link's name has priority of publication, his work having been published in 1807, whilst Miller's paper was not read before 1823, and not published before 1826. The name must not, however, be confounded with the Belemnoid genus *Atractites* of Gümbel[3] from the Lower Lias and Upper Trias.

[1] The term 'alveolus' is here used for the chambered part of the shell, but this is now known as the phragmocone, the term 'alveolus' being applied to the conical cavity in the guard that receives the phragmocone.

[2] As Link's work is very rare we have thought it advisable to give the description in Link's own words; it is as follows:—

"*Atractilites*. Atractilit. Eine spindelförmige, inwendig strahlig krystallisirte Schale, ohne Alveole.

"*A. belemniticus*. Belemnitischer Atr. Die spindelförmigen Belemniten werden von vielen Schriftstellern angeführt, aber oft verwechselt und nicht genau beschrieben. Wir besitzen an beiden Enden völlig zugespitze Exemplare. An dem einen bemerkt man deutliche Spuren einer blättrigen Textur, sonst sind sie den gewöhnlichen Belemniten ganz ähnlich. Ich habe ein Stück zerschlagen und inwendig die strahlige Bildung der Belemniten aber durchaus keine Alveole gefunden, daher man sie nicht zu der vorigen Gattung bringen kann."

[3] C. W. Gümbel: "Geognostische Beschreibung des bayerischen Alpengebirges," etc., 1861, p. 475.

Some of the forms that are referred to the genus *Actinocamax* do not exhibit the convex alveolar end referred to by Miller; a short explanation may therefore perhaps be of interest.

The form of the alveolar end of the guard in this genus depends upon the forward extent of the calcification of the component layers of the guard. All the species of *Actinocamax* possessed phragmocones. In the typical form *A. verus* the alveolar end is convex or more or less conical, the apex of the cone being sometimes occupied by a minute rounded shallow depression, indicating the position of the protoconch or commencement of the phragmocone. During the growth of the guard the alveolar portion of each component layer remained uncalcified, the extent of the uncalcified portion increasing with each successive layer (see Fig. *a*). Consequently, when during fossilization the uncalcified portion decayed and was lost, the phragmocone became detached, and the alveolar end of the guard assumed a convex or pyramidal form.

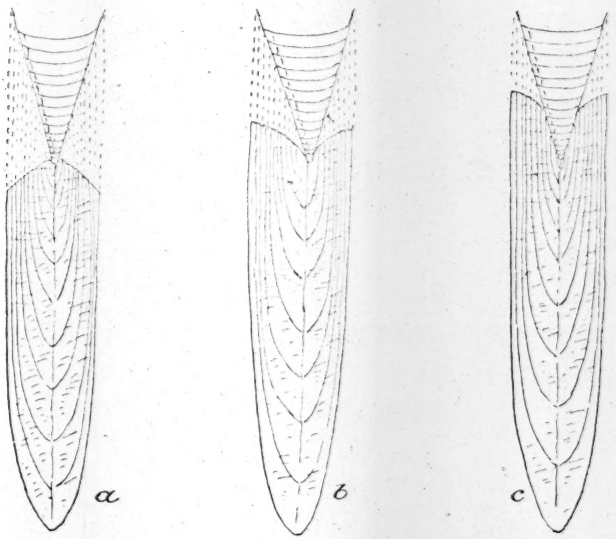


Diagram of longitudinal sections of different forms of *Actinocamax*. The dotted lines indicate the uncalcified part of the guard that is lost during fossilization. *a*, typical form, *A. verus*; *b*, *A. granulatus*; *c*, *A. quadratus*.

If during the growth of the guard the alveolar portion of each component layer remained uncalcified, whilst the extent of the uncalcified portion gradually increased with each successive layer, but much less rapidly than in the typical form, then the fossilized portion of the guard would have a conical hollow alveolar end (Fig. *b*) having an angle greater than that of the alveolus or of the phragmocone. Such a form is *A. granulatus*.

Again, if the earlier (inner) layers of the guard were completely calcified, and the rest remained uncalcified in the neighbourhood

of the alveolus, whilst the extent of the uncalcified part increased with each successive layer, but less rapidly than in the typical form, then the removal of the uncalcified portion during fossilization would produce a guard having a more or less funnel-shaped alveolar end (Fig. *c*), of which the apical or posterior portion only would form part of the alveolus, whilst the anterior part of the cavity would have a greater angle than that of the alveolus or of the phragmocone. This form of alveolar end is illustrated by *A. quadratus*.[1]

It may also be noted that the alveolar end is frequently less dense and more friable than the rest of the guard, having probably been originally less perfectly calcified; it is therefore easily broken, causing the alveolar end to present the foliaceous appearance by no means uncommonly found in *A. quadratus*.

It would therefore seem that during the progress of development calcification of the alveolar end extended further and further forward, producing a progressive deepening of the alveolar cavity. This course of development is indicated also by the observations of Dr. Rowe,[2] who points out that in the examples which he refers to *A. granulatus* there is a progressive deepening of the alveolar cavity as the Belemnite ascends in the zone.

VI.—The Descriptive Nomenclature of Ripple-mark.

By A. R. Hunt, M.A., F.G.S.

OVER twenty years ago, in 1882, I ventured to controvert a doctrine which was at the time maintained with remarkable unanimity by all geologists, and which was taught in all the current textbooks. It was that the ordinary ripple-mark of the seashore was formed by continuous water-currents of some kind; the current of water taking the place and performing the office of the current of wind which ripples the surface of sand-dunes.

As it was a question of authority and textbooks I ventured to join issue with those of perhaps the greatest weight, viz., the series of which several editions were published by Mr. Jukes and Sir Archibald Geikie. I stated my thesis, and the object of my paper, in the following plain words:—

"I shall endeavour in the present paper to prove that ripple-marks formed under water are, as a rule, completely independent of the rise and fall of tides, of tidal currents, and of sea beaches; and that they have little in common with the current-mark, that owes its origin to a continuous current of air or of water" (Proc. Roy. Soc., 1882, p. 2).

[1] This is the type-species of Bayle's *Goniotenthis*. Explication de la carte géologique de la France, publiée par ordre de M. le Ministre des travaux publics, Tome quatrième, Atlas, Première partie—Fossiles principaux des terrains, E. Bayle, 1878, pl. xxiii, figs. 6–8.

[2] Proc. Geol. Assoc., vol. xviii, pt. 4 (1904), p. 271, fig. 12.

In my recapitulation I wrote, "Marine ripple-marks are formed by alternate currents set up by waves" (Proc. Roy. Soc., 1882, p. 18).

In 1883 three very important papers were published on the subject by MM. De Candolle and Forel and by Professor G. H. Darwin, F.R.S. Thus, in March, 1884, less than two years after the publication of my own pioneer paper, I was able in a paper on Sea Beaches and Sea Bottoms to direct the attention of students of wave-action to the three important papers referred to above, and also to some earlier observations of Professor Forel published in the *Bulletin de la Société Vaudoise*, etc., for February and March, 1878. The last-named publications give Prof. Forel the right of priority so far as wave-current ripple-mark is concerned.

Professor Darwin went further than any previous experimenter by demonstrating the action of eddies and vortices in collecting loose sand into ripple-mark, as soon as the incipient ripple-marks are established. Previous observers had indicated the agents, viz. wave-currents, but Professor Darwin demonstrated their mode of action.

As soon as the above papers appeared Sir Archibald Geikie allowed them their full weight, as will appear by a comparison of the third and fourth editions of his textbook with earlier works. For instance, to be as brief as possible, in the Manual of 1872 (Jukes & Geikie) we read:—Ripple-mark "is produced on the sea-beach . . . . because of the moving current of water as the tide advances or recedes" (p. 192).

In Sir Archibald's first edition of his Textbook we read:—"Water (or air) gently agitated *in a given direction* [italics mine] throws the surface of sediment into ripples. . . . Their general direction . . . suffices to indicate the quarter whence the chief movement of the water has come" (p. 483).

In the Textbooks of 1893 and 1903 there is a complete revolution. We now read: "They have been produced by an oscillation of the medium (water or air) in which the loose sand has lain. In water an oscillatory movement, sometimes also with a more or less marked current, is generated by wind blowing on its surface. The sand grains are carried backwards and forwards. By degrees inequalities of surface are produced which give rise to vortices in the water. . . . . In regular ripple-mark the forms are produced by water oscillating relatively to the bottom and the consequent establishment of a series of vortices."

No one without a minute study of ripple-mark could appreciate the extreme accuracy of phraseology and description in the above few lines. I may, however, remark that the 'alternate currents,' for which I contended single-handed in 1882, are the actual currents in opposite directions set up by waves, and not the reversal of the direction of a steady current of wind or water created locally by vortices.

I need scarcely express my deep sense of gratitude to Sir Archibald Geikie for having so promptly recognised the importance of very unorthodox doctrines at a time when it was almost impossible to obtain a patient hearing for them in England.

In the present article I propose to call attention to the extreme ambiguity of the phraseology in common use in the discussion of sand-ripples and cognate phenomena.

With reference to the meaning of 'breadth' and 'amplitude' a distinguished mathematician writes, "I cannot regard these questions of phraseology of much importance." It no doubt matters nothing when the ideas are clear, but I feel sure that inaccurate or inadequate terms, and especially when they are avowedly descriptive terms, must end in confusion of thought.

In the case of 'ripple-mark,' Sir Archibald Geikie summarily disposes of the difficulty by rejecting all such expressions as 'current-mark' and 'ripple-drift,' which, though accurate as far as they go, are calculated to mislead. Both expressions might lead the reader to suppose that ripple-mark can only be produced by the drifting action of a continuous current of air or water, whereas current-mark and ripple-drift might well be regarded as specific forms of the genus ripple-mark.

The foregoing three terms, together with 'wave-marks' as used by Dana, are a truly misleading quartette. 'Ripple-marks' are collections of sand in the form of water-ripples. There is no pretence that they are made by water-ripples. But current-mark, a completely parallel expression, professes to describe collections of sand in the form of ripples made by a current. The 'current' here is avowedly the agent, whereas the 'ripple' is merely the illustration of the effect. In Dana's 'wave-marks,' an expression even more closely allied to 'ripple-marks,' the 'wave' is the agent and not merely the illustration. In 'ripple-drift' we have a still further element of confusion, as here 'ripple' is not the illustration, but has come to mean the actual sand, which has been collected in ripple-like forms by drifting.

'Wave-mark' would be an excellent term descriptive of ordinary marine ripple-mark were it not that 'wave' would indicate the agent, whereas 'ripple,' which is no more than a small wave, would be used in an entirely different sense. Moreover, Dana has used 'wave-marks' for a very unimportant marine phenomenon, viz., the faint mark which is very occasionally left by a wave on a sandy beach.

If ripple-marks and waves are to be subjects of discussion, it is absolutely necessary that some definite meaning should be attached to descriptive terms such as height, length, breadth, and amplitude.

We will now inquire how these terms are actually used in the case of real waves.

What do we understand by the height of a sea-wave? A sailor undoubtedly measures height from trough to crest. For instance, in October, 1887, the Admiralty communicated to the Press a letter from Captain Fisher descriptive of a voyage of the battleship "Inflexible." He mentioned that "the waves were occasionally twenty-four feet high and three hundred feet in length." This height is obviously from trough to crest, and even so, very high for the wave-length.

Physicists, on the other hand, regard height as from mean water-level to crest, unless the height from trough to crest is distinctly stated. In a letter to me in 1884, the late Professor G. G. Stokes refers to "the elevation or depression above or below mean level"; and again, "Taking it [the wave] as eight feet above or below mean level in the shoal, sixteen feet from crest to trough in all" (Trans. Devon Assoc., vol. xix, pp. 513, 514). Yet in the paper to which Professor Stokes' letter was appended, I, from force of habit, whenever I used the term height, referred to height from trough to crest. The one measurement is of course treated as being exactly double the other, though it is not necessarily so with breakers in shallow water.

What is understood by the 'length' of a wave? In the case of sea-waves, which are fairly uniform in size at the same time, English writers mean by 'length' the distance from crest to crest. If, however, we have to regard a wave as isolated, it has then but one crest, and we may treat the total length as the length of the elevated water added to the length of the depressed water, both at the level of repose of the water. What, then, is understood by the 'breadth' of a wave? This is a term rarely met with, but would probably mean the extent of a wave measured along its crest. We now come to 'amplitude.' What is the amplitude of a wave? So far as I am aware, 'amplitude' with physicists is always connected with the idea of motion, the amplitude of a wave of ether, air, or water being regarded as the extent of the oscillation or vibration of the medium, caused by the passage of a wave.

In the course of my correspondence with Lord Rayleigh and Sir G. G. Stokes on the question of sea-waves, although both those eminent physicists supplied me with much information, I do not remember a single instance of their use of the term amplitude. If used for 'height' it would be redundant, and for shore-breakers inaccurate, as in shallow water the crests contract in length, and the height of the wave from trough to crest greatly exceeds the relative height in deep water, where it is equal to the amplitude of vibration of the water itself. The increasing height of the shortening crest came out clearly in tank experiments.

We note, then, that even in the well-studied case of sea-waves, which are real waves, we have to be careful that we do not confound the height from mean level with the height from trough, and that we do not confound amplitude with either of those terms.

A difficulty has arisen owing to the indiscriminate application of the simple terms height, length, and amplitude (which in the case of true waves are technical terms with stereotyped meanings) to forms which simulate waves, such as ripple-mark, snowdrifts, and even mountains and valleys. And even so, the terms are not always used in the same sense by different authors. It is always necessary to ascertain the exact meaning of each author.

Professor Forel, in describing his ripples and experiments, speaks of the 'longeur' of his tank, and of the 'hauteur' and 'largeur' of his ripple-mark, but strictly limits 'amplitude' to the extent of the

water-oscillation which forms the ripple-mark. What to an English observer is the crest to crest *length* of ripples, is to Professor Forel their 'largeur' or 'breadth.'

Professor Darwin speaks of a "rotational oscillation with a jerking motion of small amplitude";[1] of the height of ripples, and of the 'wave-length' of ripples. With him also 'amplitude' expresses the idea of motion.

Ripple-marks so closely imitate in form motionless water-ripples (such as may be seen in a sharp current) that it is most natural to describe them by the phraseology used for true waves, such as 'height' and 'wave-length.' But even here we do well to remember that the height of a sand-ripple can never be synonymous with the height of a water-ripple, since the latter is referred to the level of repose of the water. The sand-ripple reposes corrugated as comfortably as it does flat. In fact, the height of ripple-mark is from trough to crest, and therefore does not even correspond with the 'height' of water-ripple, which is from crest to mean level.

In 1900 I was nominated by Section C a member of a joint committee with Section E to investigate 'Terrestrial Surface Waves.' I was reluctant to accept the nomination, which had been made in my absence, because, as I at once pointed out, I could see no geological bearing in the subject, which related in the first place to snow phenomena, and I knew nothing about it. On receipt of the first report I found that I was quite uncertain as to the meaning attached by the committee to the technical terms used in describing the dimensions of snowdrifts. In fact, I might go further, as I do not understand the terms used to describe the object of the committee's researches, viz. 'terrestrial surface waves.' I found that both snowdrifts and snow-ripples were described exactly as though they were real waves, and not merely wave-like forms. The following quotation will indicate my difficulty:—

"The height of these waves [of snow] was generally not more than six inches. They are flatter than the homologous æolian sand ripples, the wave-lengths being often forty or fifty times the amplitude. . . . There are also regularly undulating surfaces carved by the wind in more coherent snow . . . it is proposed to call them *undulates*" (Rep. Brit. Assoc., 1901, p. 398).

It will be observed that the geographers have captured the entire wave-nomenclature, e.g., ripples, wave-length, height, amplitude, and undulating. If we refer to Murray's Dictionary we shall find that the primary meaning of amplitude is width or breadth; that its astronomical meaning is angular distance; and that its physical meaning is the vibration of a particle. With regard to the word 'undulating,' we have Pope's line "Through undulating air the sounds are sent." The geographical and geological use of 'amplitude' to express height forces the word into a meaning in direct conflict with both its ordinary use and its derivation. Professor Lapworth, in his address to Section C, points out that the form of the "wave or fold of the geologist resembles that of the

[1] Proc. Roy. Soc., 1883, p. 2.

wave of the physicist, as also does the form of the surface-wave of the geographer" (Rep. Brit. Assoc., 1892, p. 701). No doubt geographers and geologists have as much right to the dictionary as physicists, but in the present case, the investigation of ripple-mark, the result is inconvenient for the following reason, viz., that as it is now admitted that marine ripple-mark is to a great extent made by waves, if we attempt to discuss the formation of ripple-mark in any detail the waves will require their own terminology for their own use.

The following incident illustrates the importance of exact phraseology. My Ripple-mark paper, though promoted to the rank of a much cited authority, survived eighteen years scatheless, until in 1900 my friend Dr. Vaughan Cornish stated in Section C that an error therein had misled German students. I was not surprised at the detection of an error, but at its having escaped so long. I pointed out that the alleged error was in a quotation. Dr. Cornish replied that I was held responsible for it. On referring to Professor Forel's paper I noted that he had actually quoted the censured passage, but only on the authority of its author, the Rev. John Gilmore, as cited by me. The passage had clearly not misled Prof. Forel, nor did he hold me responsible for it. What, then, had misled the German students? It was simply this. The Rev. John Gilmore, in describing the struggles of the lifeboat men on the Goodwin Sands, wrote, "The heavy seas have driven the sands into high ridges, and the gullies between these are waist-deep and full of running water with the sand soft and quick at the bottom." And again, "On the Goodwins where . . . . the waves break and the tide rushes with tenfold power, the little sand ripples of the smoother shore become ridges of two or three feet high." In referring to these ridges and gullies made by "heavy seas" and rushing tides in quicksands, I used the expression 'wave-marks,' carefully avoiding the technical term 'ripple-mark.' But, alas! I was unaware that the German equivalent for ripple-mark is 'wellenfurschen,' or wave-furrows, so the German students must naturally have concluded that when I described ridges and gullies as 'wave-marks' I meant to describe their own German wave-furrows, which are no more than the ordinary English ripple-mark and Professor Forel's 'rides du fond,' otherwise wrinkles on the bottom. I was unaware that Dana had previously appropriated the term 'wave-marks' for another purpose. No doubt it would have been more accurate to have described the ridges and gullies on the Goodwins as wave-and-tidal-current-marks; but the quotation of a record of a fact, far too valuable to lose, could not have misled experimentalists, and in fact did not do so.

It is by no means always easy to distinguish offhand true ripple-mark from corrugations in fine-grained rocks caused by pressure, and in a well-known case at the east end of Meadfoot Sands, Torquay, the evidence is conflicting. If only a squeeze it is a remarkably good imitation of the genuine article. If genuine, and a case of ripple-mark complicated by pressure in finest grits associated with slates, it is interesting as occurring in the Lower

Devonian rocks without a trace of shallow-water conditions. Associated with these corrugated rocks there is a band of some inches of badly preserved shells suggestive of some great destruction of the submarine fauna; what Gwyn Jeffreys would have described in modern seas as a charnel-house of shells. The currents were clearly sharp, but transitory, as the grit and slate beds are not confused, and the thickness of the shell band very regular. The corrugations are symmetrical, so must be wave-formed and not continuous current-formed, that is, if they are ripple-mark at all. Now in considering such a case as this we have to realise the presence of waves heavy enough to disturb depths at which fine silt and mud can accumulate. This depth, disturbed only on rare occasions, will depend on the height (crest to trough) of the waves. The amplitude of the reciprocating currents over the bottom will depend on the height (crest to trough) of the waves and the depth of the water, while the number per minute of the double currents, or their frequency, will depend on the period of the waves. Now the technical terms required for this description are height (crest to trough), length, amplitude, period, and frequency. The terms height and length will apply to ripple-marks equally well; but with amplitude, period, and frequency ripple-marks have nothing to do. If we use amplitude for the height of a ripple-mark we use a stereotyped wave-term in a different sense; while, if we use the term wave-length for the ripples, our thoughts are at once directed to the true waves which formed them, waves which really possessed wave-length, which the ripple-marks only possess by courtesy.

My own work in ripple-mark, which was undertaken solely to establish the doctrine of alternate wave-currents, received its full fruition when Sir Archibald Geikie accepted the doctrine of the "oscillation of the medium" in his textbook of 1893. That fact accepted, all the rest, the interesting consequences, must follow in time. But they will follow sooner if we can avoid confusion of ideas being perpetuated by ambiguous and even conflicting nomenclature. Were this a paper on ripple-mark itself it would be easy to run through the great textbooks and manuals and indicate where the different authors have followed the wrong trail. I will, however, quote one very useful and popular dictionary of scientific terms. In Webster's Dictionary, ed. 1876, we read, "Ripple-mark. (Geol.) A mark on the surface of a rock resembling that made by receding waves on a sea beach." Now waves on a falling tide have often effaced ripple-marks on the flats of a sea beach, but have never created them. The efficacy, or even the existence, of a *receding* wave is as imaginary as that of the efficacy of the advancing or receding tide, moving towards or from the shore at the rate of a few hundred feet or less in some six hours. The wave has ceased to exist before any water recedes from off the beach.

So far as I am aware, no paper on ripple-mark has appeared in any geological publication since Dr. Sorby's "Structures produced by the Currents, etc.," in the *Geologist* in 1859. The literature is scattered far and wide. Sir Archibald Geikie has given the

references to the papers of Messrs. Sorby, De Candolle, Forel, and Darwin. To these I would add the shrewd observations of that king among observers, De la Beche, in his "Geological Observer," and several papers by Dr. Vaughan Cornish in the publications of the Geographical Society which have appeared since I retired from the fray.

In May, 1903, I concluded a paper on Vein Quartz with a quotation from a letter written by Dr. Sorby in 1889—"There are many things connected with it [granite] about which we know much less than is desirable." Let me conclude this paper with the last few lines of the same author's 1859 paper on the "Structures produced by Currents": "Those [experiments] which I have made already, though not nearly sufficient to clear up many highly important questions, are still sufficient to give very great encouragement; and I therefore feel anxious to induce others to turn their attention to this branch of research, being convinced that it cannot but yield a bountiful harvest of fact when studied with perseverance and zeal." To this conviction, now forty-five years old, we may still add our fervent Amens.

P.S.—Since the above was written, I received, on the 1st of July, *Nature* for June 30th, and Dr. Nansen's "Bathymetrical Features of the North Polar Seas," etc. Dr. Nansen observes (p. 137), "ripple-marks, however, are not merely formed by waves, but also by currents." *Nature*, referring to experiments made by Mr. F. Ayrton at the Royal Society conversazione, asserts, with the emphasis of italics, "It was also shown that ripples are *not* produced by a *steady* current of water flowing over sand." Dr. Vaughan Cornish writes: "The true current-formed sand-wave I find to be produced as soon as the velocity of the stream causes the water to be turbid with a heavy charge of sand in eddying suspension. The process can be watched in the shallow streams of sandy tidal foreshores" (Geographical Journal, August, 1901, p. 198). I have noticed this result myself.

In the same paper (p. 200) Dr. Cornish writes, "Professor Osborne Reynolds found that in his model estuaries the ripples 'formed by the alternating action of the tide' had a wave-length equal to twelve times their amplitude ($\lambda = 12$ H)."

If Professor Reynolds used the terms wave-length and amplitude I should have to retire discomfited, as I had the honour to serve on his committee; but I find that what Professor Reynolds wrote was, "Some of the ripples were from hollow to crest as much as one-fourth the mean-rise of the tide, the distance between them being twelve times their height" (Rep. Brit. Assoc., 1889, p. 343). Professor Reynolds avoids the technical wave terms.

The apparent contradictions of writers on ripple-mark are so surprising that one fails to see how the student, or even the text-book writer, can find his way through the mist. However, the contradictions are easily explained, as there are several ways of producing rippled sand-surfaces. If not trespassing too much on

the patience of the readers of the GEOLOGICAL MAGAZINE I should like some day to make an attempt to show how the trick is done, and how ripple-mark concerns geologists, not as a mere unimportant detail of rock-structure, but as an important factor and index in the great problem of marine erosion. In the meantime I may refer to Dr. Nansen's admirable epitome of the evidence of marine erosion in his work above referred to, and also to Dr. Cornish's papers in the Geographical Journal.

VII.—CONTRIBUTIONS TO THE GEOLOGY OF CEYLON: III. THE BALANGODA GROUP.

By A. K. COOMÁRASWÁMY, B.Sc., F.L.S., F.G.S., Director of the Mineralogical Survey of Ceylon.

THE name 'Balangoda group' is proposed for a series of granitic and pegmatite-like rocks, intrusive in, but distinct from, the Charnockite series; first met with in the Balangoda district, but evidently widely distributed over a large area between Balangoda and Hatton. The rocks are best described as granites, but occur most often in rather narrow dykes, after the manner of pegmatites. Yet there is no reason for separating the smaller from the larger masses, and the term granite is applied to both. The group (of which a more detailed account will ultimately be needed) includes in particular zircon granite, allanite granite, magnetite granite, and granite without conspicuous accessory minerals; as well as the probably similar rocks in which the hitherto unlocated minerals geikielite, baddeleyite, rutile, fergusonite, thorite,[1] thorianite, etc., may be looked for; and the vein of pegmatite at Gampola, which consisted of quartz, felspars, and biotite, with apatite, ilmenite, tourmaline, and the new mineral described as thorianite [2] as accessory minerals.

These granites are intrusive in the Charnockite series, and though frequently occurring in lenticular masses (Denagama) with a disposition parallel to that of the foliation planes of the charnockites, have often been observed to transgress these foliation planes and to behave as intrusive rocks. Contact phenomena have not, however, been observed, except perhaps in a slight tendency to a peripheral fineness of grain in the intrusive rocks. At the junctions granite and charnockite are usually welded together, there being no absolutely hard line of separation, although the junction may be called sharp; in the case of the larger masses no good junctions have been seen.

A description of the rocks is given below, with special reference to the localities where they can be seen:—

Zircon granite.—This rock was seen *in situ* at several points, and is the best known member of the group. The finest and longest exposure is on Massena estate, six miles from Balangoda; here a considerable mass of granite, fully two miles in length and

[1] W. Dunstan, *Nature*, 1904, p. 510.

[2] "Spolia Zeylanica," vol. i, pt. 4 (1904), p. 112; and *Nature*, loc. cit.

averaging perhaps a hundred yards in width, runs, parallel to the Charnockite foliation-strike, along the trough-like strike valley of the Massena Oya, in which the main part of the estate is found. The rock occurs in enormous masses, both *in situ* and in great boulders, amongst which the Massena Oya finds its way. Two rows of curiously weathered masses stand out of the swamp below the bungalow; good specimens very rich in zircon can be collected here. The rock usually shows no trace of foliation in small specimens; but foliation (vertical, with strike about 15° N. of W.) is evident in an exposure *in situ* near the middle of the estate, near the 'lines.'

The rock consists essentially of quartz, felspar, and biotite, with zircon and ilmenite as characteristic accessory minerals, and apatite as a microscopic constituent. The content of zircon varies greatly from specimens in which a crystal can hardly be found to others

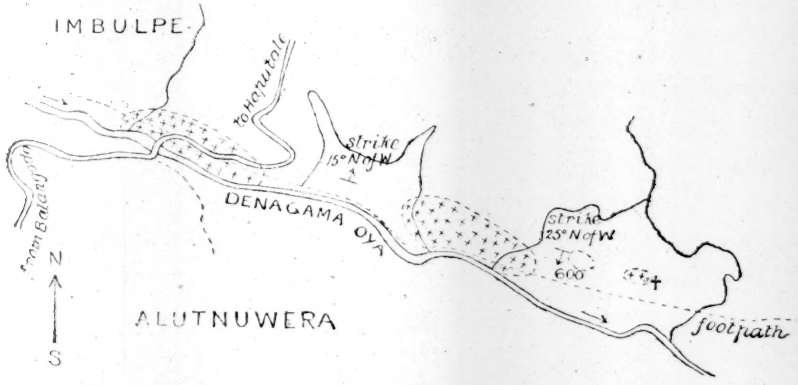


Fig. 1.—Rough sketch-map of zircon granites near Denagama Oya bridge, near Balangoda, Sab, Ceylon. ××× zircon granites; † zircon granites well foliated. Scale, 5 inches = 1½ miles.

in which it forms a noteworthy proportion of the rock. The zircon occurs in moderately good, idiomorphic, stumpy, prismatic crystals, generally terminated, the forms *m* (110), *a* (100), *p* (111), *e* (101) being certainly present; the colour is hair-brown, often quite pale; in thin section no colour is seen; the longest individuals exceed $\frac{3}{32}$ inch in length, but most are somewhat smaller. The rock itself is relatively fine-grained, the quartz and felspars rarely exceeding in diameter the length of the longest zircons. The felspars include orthoclase (sometimes microperthitic) and an acid plagioclase with s.g. near to that of orthoclase. The biotite occurs in ragged crystals, macroscopically nearly black, but brown in thin section, and with pleochroism from warm brown to pale straw colour. Ilmenite is common, occasionally moulding the zircons, and generally partly altered to 'leucoxene.' Apatite is fairly abundant in six-sided terminated prisms about $\frac{1}{100}$ inch in length. The general structure is hypidiomorphic, only the zircon and apatite occurring in well-developed crystals.

Another exposure (Map, Fig. 1) is seen near the bridge over the Denagama Oya, about 6 miles from Balangoda on the Haputale road. Small idiomorphic zircons ($\frac{1}{16}$ inch) are scattered sparingly in the rock, which resembles that of Massena estate, but is of somewhat coarser grain. Ilmenite is common, the zircon quite scarce. Other exposures are found along the line of strike on the left bank of the stream. The granite seems to form a series of lenticular masses. At one point the rock becomes well foliated (as if by pressure), the small crystals of biotite being closely packed and sweeping round the augen orthoclase. Well-formed zircons $\frac{3}{8}$ inch in length are to be found.

A similar foliated zircon granite is exposed by the roadside $1\frac{1}{2}$ miles further on, just beyond the 91st milepost; the zircons vary from $\frac{1}{16}$ to $\frac{1}{8}$ inch in length, and are of the usual light-brown colour.

No junctions were observed in the instances above referred to.

Near Haldummulla and about 18 miles from Balangoda a small granitic dyke was seen in the Weli Oya valley about half a mile above the road, crossing foliation in the Charnockite series and containing a few minute zircons just visible to the naked eye.

In the Bamberabotuwa district a large number of small intrusive pegmatites or granite dykes were examined on Hopewell estate (15–16 miles from Balangoda), where they are well exposed, and cross the foliation of the Charnockite series in all directions; only two were found to contain minute crystals of zircon sparingly distributed. Zircon may occur in others, but so rarely as to be overlooked. This exhausts the list of localities where macroscopic zircons have been seen *in sitâ*.

Zircons of all sizes (up to $1\frac{1}{2}$ inches or more) occur abundantly in every stream and river gravel, and are found in quantities when gemming operations are carried on, joining a large proportion of the heavy residue (*nāmbu*[1]) at the bottom of the gemming-basket: the clear-coloured varieties are of value as gems; the remainder is rejected. The irregular zircons described by Mr. Spencer[2] occur in this way in various parts of the Balangoda and Bamberabotuwa districts. Near Kondrugala zircon is very abundant in large individuals. Well-developed twins on *e* (101) are found. With the zircon are associated 'thorianite,' thorite, ilmenite. Large zircons have also been found in gemmings from the Hatton district. Zircon is also abundant over a wide area in the Southern Province in the Galle, Matara, and Morawaka districts, and no doubt also at Rakwana; the same rocks may be expected to be met with in these districts.

Allanite granites.—Allanite granites are well exposed in two places in the Balangoda districts. It is some years since Mr. W. D. Holland discovered a granite or pegmatite dyke, crossing foliation in the Charnockite series, in the bed of the Wewel Dola near the lower end of his estate of Dik Mukulana, and containing allanite in some abundance. The determination of allanite was confirmed

[1] A Sinhalese term which may with advantage be adopted.

[2] *Nature*, April 14th, 1904, p. 575.

by a partial analysis made for Mr. Holland, and by Mr. G. T. Prior, to whom a sample was submitted. The granitic dyke is composed of quartz, felspar, hornblende, allanite, biotite, pyrite.

The felspars include porphyritic orthoclase and also a series of smaller individuals of orthoclase and plagioclase (some of the latter are porphyritic like the orthoclase), forming with quartz the finer-grained portions of the dyke. Allanite and hornblende occur in varying amount, both being locally very abundant. Biotite is scarce. Pyrite occurs chiefly in secondarily deposited films.

A better exposure of allanite granite is found in the lower part of Denagama estate, about seven or eight miles from Balangoda. A conspicuous dyke, three to four feet thick, crosses the left branch of the stream, which runs through the tea below the path, and forms a conspicuous ledge inclined at a low angle to the foliation. The granulites are inclined at a very similar angle, but it can be seen clearly that the dyke does not keep strictly to the foliation planes; moreover, a few short processes, six inches to a foot in width, project into the rock underlying the dyke, clearly showing the intrusive character of the latter. The dyke is coarse-grained, and consists mainly of orthoclase (porphyritic idiomorphic individuals often about 3×1 inches), quartz, and biotite, the latter in long thin crystals (measuring e.g. $9 \times 1 \times \frac{1}{4}$ inches) scattered in all directions through the rock.

In these two dykes the allanite is very unevenly distributed, being in places very abundant, and elsewhere almost or quite absent. The allanite forms thin tabular idiomorphic as well as more irregular individuals; the largest attain a length of three inches, those of medium size measure about $1 \times \frac{1}{2} \times \frac{1}{4}$ inch. A curious point is that the allanite seems to form a centre for radiating cracks in the rock, giving it a rather conspicuous appearance, of which a diagram is given in Fig. 2 (Denagama).

The allanite is macroscopically black (in thin section brownish olive-green), and has a resinous lustre and conchoidal fracture; hardness about 6; sp. gr. 3·2 to 3·5; before the blowpipe it intumesces strongly.

Magnetite granite.—A small dyke 2 inches wide and of the usual character, but containing irregular individuals of magnetite about $\frac{3}{4}$ inch in diameter, was seen in the bed of the Wewel Dola at Dik Mukulana. Another dyke 6 inches wide, containing similar magnetite, was observed on Hopewell estate.

The Gampola pegmatite.[1]—This rock consisted mainly of orthoclase, quartz, and biotite, and contained apatite, tourmaline, ilmenite, and uraninite ('thorianite') as accessory minerals.

Granites without conspicuous accessory minerals.—These are of fairly general distribution in the Balangoda district, sometimes occurring in the form of dykes (usually less than three feet in width) in very considerable abundance. It is possible that a much more extended search might reveal the presence of macroscopic zircons in some of these rocks; for the most part, however, they

[1] "Spolia Zeylanica," vol. i, pt. 4 (1904), p. 512.

are similar to the granitic rocks described above, but without the characteristic accessory minerals. There is a considerable exposure of reddish granite on the Ratnapura road about a mile below Balangoda, and this is known as a locality for 'graphic granite.' A tendency to graphic structure was noticed in many of the rocks already described. Smaller masses (dykes) are common at Dik Mukulana (11 miles from Balangoda) and on Hopewell estate,

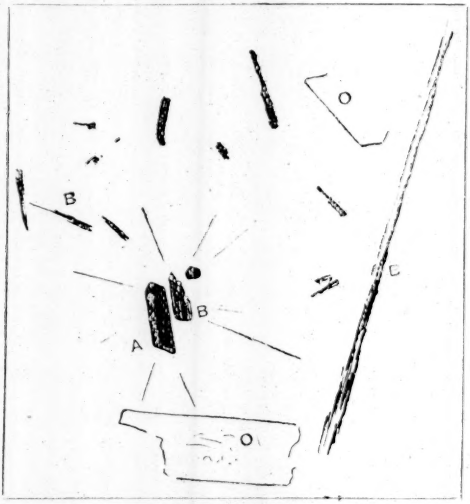


FIG. 2.—Structure of allanite granite; Denagama estate, Balangoda. *A*, allanite; *B*, biotite; *O*, orthoclase; remainder quartz and felspar. Present scale, × 5½ times.

15 miles from Balangoda, and at many other points. These granites (as well as others containing zircon) are also well exposed on Herimitegala estate, about 8 miles from Balangoda.

The list of types of rock belonging to the Balangoda group actually met with is now exhausted. There can be no doubt that many other varieties will be found, and it is evident that some are likely to be of great interest. Since, however, detrital zircon is exceedingly abundant, yet is known *in situ* in a few localities only, it is clear that the chance of finding any particular one of the other and rarer minerals *in situ* must be rather small.

REVIEWS.

I.—Dr. Fridtjof Nansen's Researches into the Bathymetrical Features of the North Polar Seas.[1]

THIS elaborate volume is the outcome of Dr. Nansen's Arctic Explorations, of which we have narratives in his "First Crossing of Greenland" (1890) and his "Farthest North" (1897), both

[1] Published by the Fridtjof Nansen Fund for the Advancement of Science (with 29 plates). Christiania, 1904.

delightful works of travel and adventure in inhospitable and little-known regions, and fortunately for most of us Britishers written in the English language. The most recent volume here under our notice deals with those great problems of submerged lands and ocean basins for the most part held fast in the embrace of perennial ice, and of which the depth can only be known by the sounding line let down through the ice-cap itself. As well known, "Nansen's Farthest North" was reached on the 7th April, 1895, in N. lat. 86° 13′ 6″, where the depth of the ocean reaches 3,000 metres, a depth which may be presumed to extend to the pole itself. Certain it is that deep ocean water is under the North Pole; not "an open sea," as was once announced by Kane, the American Arctic explorer. The whole structure and arrangement of land and sea, whether ice-covered or open, is admirably represented in the bathymetrical chart of the North Polar Seas which accompanies Nansen's recent volume, and under its guidance I propose to consider some of the suboceanic features which arrest attention. The centre of the chart being the pole, it embraces in its circumference all the region bordering on both sides the Arctic circle; and on looking at the chart we are at once struck by three leading features indicated by distinctive colours—the lands, by dark shade; the continental shelf or platform, by yellow; and the deep ocean, by various shades of blue. The varying depths are all worked out by isobathic lines founded on the soundings, a system of suboceanic delineation hitherto much neglected by British cartographers, but capable of opening up many new facts of suboceanic geography; this, indeed, is the only way of placing before us in a graphic manner the various physical features below the waters of the ocean, whether they be terraces, old river valleys, gulfs, or deep ocean. Of this system of illustration Dr. Nansen has made abundant use both for pourtraying the form of the sea-floor and for plotting transverse sections similar to those which may be drawn by means of contour-lines to illustrate the form of the land.

The continental shelf is continuous all round the margin of the land with the exception of one remarkable interval lying along the meridian of Greenwich between Spitzbergen and the north-east corner of Greenland, where the floor of the ocean bed rises to within 786 metres of the surface in the form of a narrow bank descending rapidly into the deep water of the Arctic Ocean on the one side and into that of the Norwegian Gulf on the other. It is, in fact, a submerged saddle. The narrowest part of the continental shelf lies off the Lofoten Islands, but spreads in a broad nearly level sheet all round the coast of the Europe-Asian Continent to that of the North American Continent. From its surface rise the Spitzbergen and Franz Josef groups of islands, together with Novaia Zembla and the New Siberian Islands. Its average depth near the outer margin may be taken at 200 metres, but in some places it is over 300 metres. All the way from Spitzbergen along the Europe-Asian Continent it breaks off in a steep declivity, descending into the Arctic Ocean by gradients varying from $5\frac{1}{2}$ to 20 degrees in steepness; the

steepest portion of the declivity being situated between depths of 200 and 1,000 metres. Thus it will be seen that there is a remarkable similarity in the bathymetrical conditions of the polar regions and those of the North Atlantic; in both there is the continental shelf, and the steep exterior slope or declivity, leading down to the floor of the outer ocean at depths of about 2,500 metres (8,140 feet). But another point of similarity is the existence of channels or 'fjords,' traversing the platform and opening out on the ocean at great depths. Some of these submerged fjords decrease in depth towards their outlet on the deep ocean, as for example the Vardœ Murman Channel along the coast of East Finmarken, resembling in this respect the Norwegian fjords. The cause of this shallowing of the submarine fjords is necessarily obscure, but is in all probability partly attributable to glacial moraine matter piled up at the Glacial Period upon the melting of the ice. On a former occasion I have dwelt upon this remarkable feature in the case of the Norwegian fjords.[1]

In addition to the continental shelf, there occurs a feature not generally recognised on the Atlantic border, called by Nansen "the coast platform" (strand fladen), descending to only a few metres (10 to 15) below sea-level and covered by numerous shoals and sunken rocks. The coast-platform is often incised by channels parallel to the coast or outer margin of the platform itself. The formation of the marginal shelf is discussed by the author, who regards it as "a comparatively young formation, the greater part of which must have been formed after the Norwegian Continental Shelf" (p. 112). If this be so, the coast-platform would appear to be a "raised beach," formed after the continental shelf during the period of the rise of the land at the close of the Glacial Period.

Those who doubt the existence of suboceanic river valleys will not find support from Dr. Nansen. According to this author, the Europasian continental shelf is seamed by numerous submerged channels. The Norwegian fjords are often continued under the waters of the outer sea, descending to depths of 400 metres (1,312 feet) or more. In the neighbourhood of the Franz Josef Islands good examples of submerged valleys are indicated; others occur north of Andoe. At the same time the author considers that in some cases the deep channels may be due to faulting. The submerged valleys are not shown on the bathymetric map, which is on too small a scale for the purpose, but they are shown on the sections, of which there are many in the volume of great interest. It is to be regretted, however, that Dr. Nansen has adopted a scale so exaggerated as 1 in 50 for the vertical; the result of which is to cause the hills and elevations on the land side to take the appearance of the spires of churches! A scale of 1 in 10 would have been sufficient for the delineation of the features, and would have appeared less unnatural.

The volume is accompanied by a fine geological map of Norway, and the isobathic contours by which the features of the submerged

[1] "The Physical History of the Norwegian Fjords": Trans. Victoria Institute, vol. xxxiv (1902).

lands and sea-bed are determined are carried out all over the ocean as far as the soundings have permitted. There can be no question that this work is the most important contribution to our knowledge of the Arctic submarine features which has yet appeared, and the author embodies in it as far as possible the work carried out in the same field by other explorers. EDWARD HULL.

II.—FOSSIL FLORAS OF CAPE COLONY. By A. C. SEWARD, M.A., F.R.S., etc. (Annals of the South African Museum, vol. iv, part 1; 122 pages, pls. i–xiv, and 8 text-figures. 1903.)

THIS memoir is undoubtedly one of the most important and complete that has yet appeared on the South African fossil floras. It contains a full description and many figures of the specimens collected by the Geological Commission of Cape Colony from four distinct formations.

Beginning with the flora of the *Uitenhage series*, among the ferns described and figured may be noticed *Onychiopsis mantelli* and *Cladophlebis browniana*, both of which occur in the Wealden of Sussex. Numerous fronds of the Cycadophyta are figured, especially of the genus *Zamites*, and also a new species of *Nilssonia*. *Araucarites Rogersi* is described as a new form of Araucarian cone. The author concludes that the "Uitenhage plants include types in part characteristic of Wealden and in part indicative of Jurassic floras. On the whole there is a balance in favour of a Wealden horizon."

The next flora described is that of the *Stormberg* beds. The following new species are among the plants figured:—*Schizoneura krasseri*, also known from China, *Callipteridium stormbergense* and *Chiropteris zeilleri*, two fine fern-like fronds, the latter being known from a single specimen in the British Museum, and *Baiera stormbergensis*, a large leaf of the Ginkgo type. Species of *Thinnfeldia*, *Tæniopteris*, and other genera typical of the Rhætic period, are also described and figured.

Among the plants of the *Ecca series*, in addition to *Glossopteris* and other well-known members of the Glossopteris flora, several genera of considerable importance are described from South Africa for the first time. *Neuropteridium validum*, already known from beds of similar age in India and South America, is represented by a large frond of which a figure is given. A new species of *Psygmophyllum*, *P. kidstoni*, is described; a type of leaf doubtfully referred to the Ginkgoales, which also occurs in the Permo-Carboniferous rocks of Europe. The Lycopodean genus *Bothrodendron*, represented by a new species, *Bothrodendron leslii*, is recorded for the first time as occurring with members of the Glossopteris flora; a further example of the association of northern and southern generic types in the Permo-Carboniferous rocks of South Africa.

Lastly, from the *Witteberg series* (? Devonian), an obscure fragment of a Lepidodendroid plant and examples of *Spirophyton* are figured. The nature of the latter is discussed, and the conclusion is held that these 'fossils' do not represent the remains of plants.

III.—Annals of the South African Museum, Vol. IV, Part 3: Brachiopoda from the Bokkeveld Beds (pls. xx–xxiii); by F. R. C. Reed, M.A., F.G.S.—Part 4: The Trilobites of the Bokkeveld Beds (pls. xxiv–xxviii); by Philip Lake, M.A., F.G.S.—Part 6: Mollusca from the Bokkeveld Beds (pls. xxx–xxxii); by F. R. C. Reed, M.A., F.G.S. 1903–1904.

THESE three papers on the fauna of the Bokkeveld Beds of South Africa introduce to us a number of interesting forms, many of which are new species. The plates of illustrations are good, and the text bears evidence of very careful work on the part of the two authors. The Devonian age of the Bokkeveld Beds is apparently settled, and the authors agree in stating that the South African species of this date show a remarkable agreement with the forms of both North and South America, and yet a dissimilarity from those of Europe. This is the conclusion of Mr. Reed (pp. 192, 193) from a study of the Brachiopods, and he gives a comparative table of the South African and South and North American species. Then Mr. Lake says of the Trilobites that they show "that the beds may be referred with certainty to the Devonian, and it is probable that they belong to the lower division of that formation. Few of the forms have any near allies in Europe. . . . . The Phacopidæ, on the other hand, are much more closely allied to the forms which have been described from Brazil and Bolivia" (p. 202). And of the Mollusca Mr. Reed says, "The evidence of the Mollusca points the same way as that of the Brachiopoda, and emphasizes still more strongly the affinities of the fauna with that of the American Continent" (p. 269).

One irritating practice we should like to bring to the notice of the editor of these Annals—that the explanations do not face their own plates; such is the case in Parts 3 and 4, but in Part 6 it is accomplished by turning one plate the wrong way and making one leaf do double duty. Even this is bad, and surely it is not worth the paper saved. In our opinion all plates should face the same way; and each plate should have its own flyleaf, bearing its own explanation and no more, opposite to it. With this exception both authors and editors may be congratulated on an excellent publication. And we may ask why the British Museum of Natural History does not publish similar Annals, and so make known to the world the wealth of new species which it contains? S. S. B.

REPORTS AND PROCEEDINGS.

Geological Society of London.

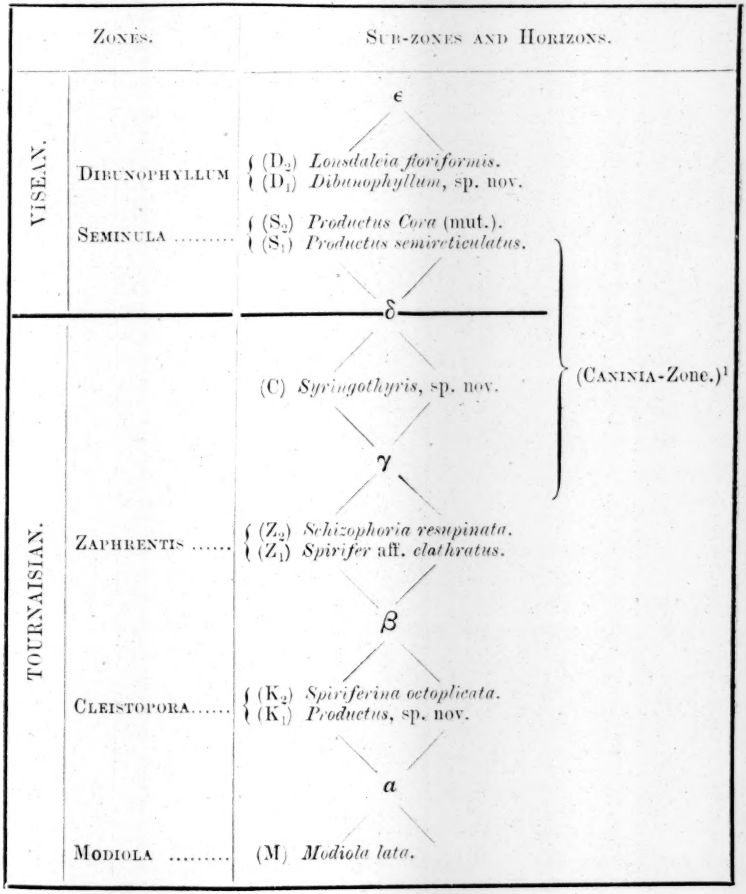
June 8th, 1904.—J. E. Marr, Sc.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Palæontological Sequence in the Carboniferous Limestone of the Bristol Area." By Arthur Vaughan, Esq., B.A., B.Sc., F.G.S.

The zonary divisions established by the author are given in the

table on p. 101 in the form in which they are finally set out, after emendation and further revision of a preliminary working system.

For several reasons the author chooses the corals and brachiopods as zone and sub-zone fossils, and he has selected genera for zone-indices and circuli (or species-groups) for sub-zonal indices. A circulus is defined as an aggregate of all the species which possess, in common, a large number of essential properties, and are the results of similar chains of evolution. To secure definiteness photographic figures are introduced, not only to illustrate new specific names, but to convey the precise sense in which well-known specific names are employed in the paper. The relative acceleration of the two groups employed is not identical in different localities, and there is a small relative displacement of one group upon the other, even within the area considered by the paper. The strata in



[1] Employed throughout the preliminary working system.

which the indices of two successive zones are found to overlap one another are referred to as 'horizon α, β, γ,' etc.

The detailed stratigraphical portion of the paper deals with all the important sections and isolated exposures in the Bristol area:—The Avon section, the Sodbury section, the Farland area, the Tytherington section, the Clevedon and Portishead area, isolated exposures, and the Backwell-Wrington mass. In each case there is given (1) a description of the position at which each zone or sub-zone is exposed and of its lithology; (2) a list of the corals and brachiopods found in the zone or sub-zone, with notes on their abundance; (3) a comparison with the same horizon in other parts of the Bristol area, and notes on the peculiarities of the section under discussion. In dealing with the Avon section an analysis is given of Stoddart's paper, and reference is made to his collection. The details of this portion of the paper are next summed up in tables and discussions of the ranges and maxima of the corals and brachiopods within the Bristol area. This is followed by a comparison of the last-named area with that of the Mendips, resulting in the conclusion that, when allowance is made for small variations (which are tabulated) the palæontological sequence agrees remarkably in the two areas.

The author next gives a summary of M. Lohest's discussion of the parallelism of the Belgian sequence with that of the Avon section, and adopts the Belgian divisions of Tournasian and Visean for the lower and upper parts of the Carboniferous Limestone. A comparison is also instituted with M. Mourlon's grouping, and it is remarked that the Brachiopods mentioned by M. Mourlon and Professor Dewalque occur in the same order in the Bristol area as in Belgium, and are correspondingly characteristic of the beds. The author claims that in the area with which he deals, his table of ranges is sufficient to enable any worker to zone any exposure with a considerable degree of accuracy. In conclusion, notes are given on all the important species and circuli dealt with; and descriptions of a number of new species, circuli, and mutations.

2. "On a small *Plesiosaurus* Skeleton from the White Lias of Westbury-on-Severn." By Wintour Frederick Gwinnell, Esq., F.G.S.

The remains described were found on the beach, and had evidently recently fallen from the cliff above, which is made up of the Upper Rhætic beds, including the *Estheria*-bed and the White Lias Limestone. The matrix of the specimen corresponds with the White Lias in colour, texture, and material, and it is similarly traversed by fissures often coated with dendrites. The remains include more than twenty small dorsal vertebræ, with spinous and transverse processes, lying in natural sequence. A pseudomorph of the spinal cord in calcite occurs also in position. Several slender ribs, and indications of other bones, probably from the pectoral or pelvic arches, also occur in the slab, but are not yet worked out. Hitherto only single vertebræ or fragmentary bones of *Plesiosaurus* have been recorded from this horizon in Britain. At present it has not been found possible to assign the fossil to any existing species.

3. "The Evidence for a Non-Sequence between the Keuper and Rhætic Series in North-West Gloucestershire and Worcestershire." By Linsdall Richardson, Esq., F.G.S.

The section at Wainlode Cliff shows a transition in the 'Bone-bed' from a thin pyritic stratum of an inch or so in thickness and crowded with fish-remains to a micaceous sandstone-bed, usually devoid of such remains and about a foot thick, but containing Strickland's *Pullastra arenicola*. This sandstone is seen in many Worcestershire sections, and may be called the 'bone-bed equivalent.' Thus, as the bed which is full of vertebrate remains, or the Bone-bed (Bed 15 of the author's sections), can be traced in a single section laterally into a sandstone-bed devoid of those remains, the contemporaneity of the two developments is considered satisfactorily established. Particular stress is laid upon the fact that above this main 'Bone-bed' the component deposits of the Rhætic are remarkably persistent, while below it such persistency is not found. Black shales are generally present below the Bone-bed or its equivalent in Worcestershire, but in places there comes in a sandstone between them and the 'Tea-green Marls.' At Dunhampstead the Rhætic rocks are thicker than at any other locality in Worcestershire. At Denny Hill, near Gloucester, the 'Bone-bed' rests directly on the 'Tea-green Marls'; there is no infra-Bone-bed deposit of Rhætic date. At Garden Cliff, however, a comparatively thick accumulation is seen in that position. The anticlinal and synclinal areas established in the Mid and North Cotteswolds by Mr. S. S. Buckman are referred to; and it is found that the greatest thicknesses of the Rhætic rocks under the Bone-bed coincide with synclines, and the least thicknesses with anticlines. The Moreton and Birdlip anticlines are especially mentioned, as also the syncline of Cleeve Hill and that between Painswick and Stroud. Thus Dunhampstead, where the Rhætic deposits below the Bone-bed are thicker than anywhere else in Worcestershire, is situated on a continuation of the Cleeve Hill synclinal axis; Denny Hill, where the 'Bone-bed' rests directly upon the 'Tea-green Marls,' is near the westward continuation of the Birdlip anticline; and Garden Cliff, where the infra-Bone-bed deposit is thickest, is situated on a continuation of the synclinal axis which runs near Painswick. Thus the earth-pressures recognized in later times were probably at work at the close of the Keuper Period. As the area, once covered by the waters of the Keuper sea and the diminished representatives of that sea in the form of lakes, gradually sank, the Rhætic ocean slowly encroached upon the land-surface, flowing up the depressions in the undulating expanse of marls, and successive overlaps of the several infra-Bone-bed deposits resulted: the greatest overlap apparently taking place during the formation of the Bone-bed. At those localities where the distribution of the infra-Bone-bed deposits indicates elevation of the Keuper Marls in immediate pre-Rhætic times, it is noticeable that there is also a non-sequence at the base of the Lias.

CORRESPONDENCE.

THE 'YOREDALE' ROCKS OF NORTH DERBYSHIRE.

SIR,—I was pleased to see in your last issue Mr. J. A. Howe's protest against the application of the term 'Yoredale' to the series of rocks which are found between the Millstone Grits Series and the Massif of North Derbyshire.

The name 'Yoredale' was first used geologically by Phillips in his "Geology of Yorkshire," pt. ii, pp. 36–7, and he leaves no doubt as to the character of the group of rocks to which he applied the term. "We shall choose as a general standard of reference for this complex series of rocks, that district where this character of complexity is the greatest. The upper end of Wensleydale is adopted. The total thickness of the Upper Limestone Series in this situation is about one thousand feet, and it consists of the following groups—constituting what I term *the Yoredale Series.*" Hereafter follows the succession of the beds from the Main Limestone to the shales below the Hardraw Scar Limestone of that district, a series having perfectly definite lithological and palæontological characters, and anyone who has visited the vale of the river Ure will have been delighted with the 'country' selected as the 'type.'

Unfortunately for students, however, Phillips also described, as belonging in part to the Yoredale Series, another and widely different development of rocks, whose position had evidently puzzled him greatly, for their description, with peculiar inconsistency on the author's part, comes under the heading "Millstone Grit Series in Craven" (p. 72). It is this development whose correlative occurs in the Peak District, but which is totally unrepresented in the Yoredale area, and which, for that reason, it is wrong to denominate 'Yoredales.' Farey's term, 'the limestone-shales,' although by no means an ideal name for the group, has right of priority, and at any rate possessed the negative virtue of causing no confusion or misconception as to the character or position of the measures; nor did it commit the user to any theories.

The series under discussion is a very important one, whose thickness in places is 1500 feet; it gives to the localities of its development surface features which are totally different to those of the typical Yoredale country; it contains a characteristic fauna; and it is worth a distinctive name.

Familiarity with both types leads me to commend the wisdom of selecting such a name as 'Pendleside Series' for this group, and I believe the distinction thus marked cannot fail to be of service to workers in the science.

JOHN T. STOBBS.

DUNELIN, BASFORD PARK, STOKE-ON-TRENT.
21*st July*, 1904.